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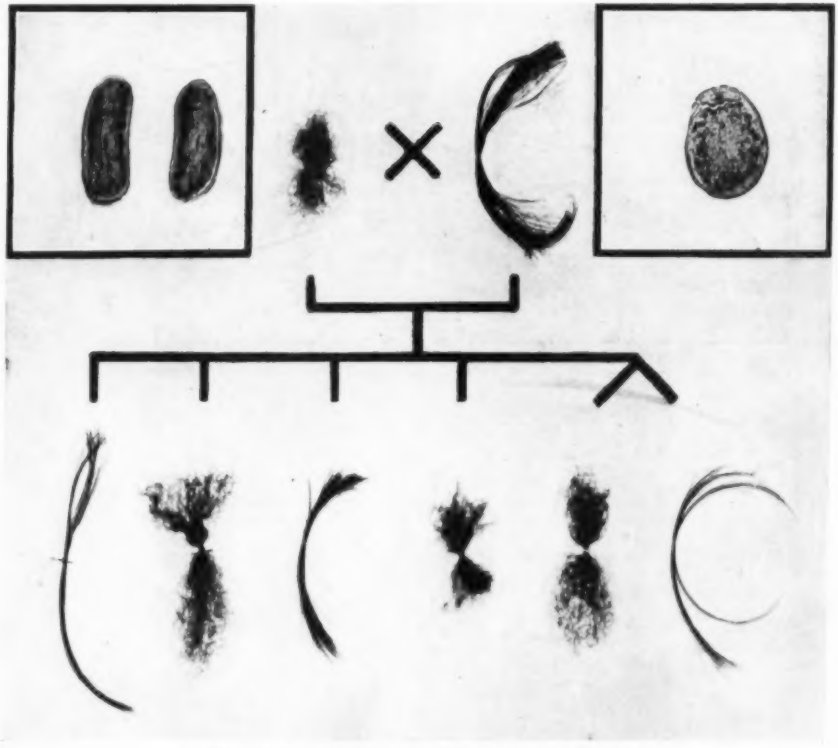

A PHOTO-PEDIGREE OF HAIR FORM
(SEE PAGE 337)

Inherited Tremor in Young Chicks

The Vanishing Descendants of Francis Scott Key

Environmental Influences on a "Qualitative" Character

Contrasting Reactions of an "Extra-Toe" Gene

Brazilian Pigs With Wool Instead of Hair

VOLUME 25 SEPTEMBER, 1934 NUMBER 9

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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A peculiar physical malformation showing clear evidence of a genetic basis.

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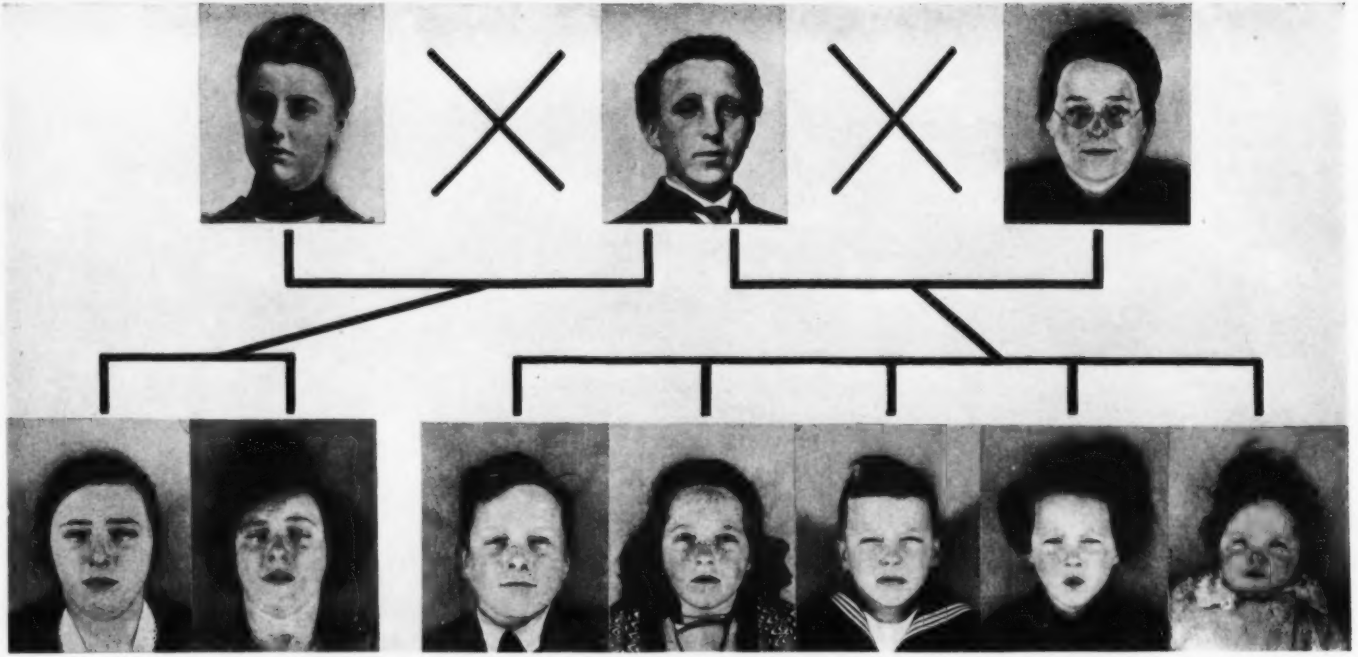


A PORTRAIT PEDIGREE CHART OF INHERITANCE OF WOOLLY HAIR

Frontispiece

A Dutch peasant family living near Leiden carries a dominant gene for a type of woolly hair characteristic of the Negro races. This is not to be explained as due to race crossing for two reasons. In the first place there is no tradition in this family of an infusion of Negro blood and no other evidence of anything but a pure Dutch ancestry. Furthermore, hair form behaves in racial crosses not as a simple dominant character but as a "blending" character (in which two or more genes are involved). Thus simple mendelian inheritance of hair form is not found in Negro-white crosses. Among such hybrids various degrees of curly and wavy hair are observed, and in later generations woolly hair may appear but only where both parents are partly Negro. Thus the occurrence of woolly hair in this family is clearly due to mutation rather than to race hybridization.

ANOTHER WOOLLY-HAIR MUTATION IN MAN

C. PH. SCHOKKING*
Rotterdam, Holland

WHILE studying twins in Leiden in 1929 and 1930, I encountered a pair of non-identical twin sisters, one of whom had remarkably curly hair. Since little is known of the inheritance of such genuine woolly hair among Europeans, I followed up the history of this pair. It soon transpired that in the village of Rijnsburg, near Leiden, whence the girls came, many woolly-haired persons were to be found, and that all of these belonged to the same family. After a deal of effort I was able to put together a pedigree chart covering five generations (Figure 3). The founder of the family had already died and no photograph of him was to be had, but an old Rijnsburger, who knew both this man and his father, was able to give me definite information that both of them had woolly hair.

I was able personally to interview most of the members of the family who are still living, and to collect specimens of their hair. Of those who had died, photographs were obtainable in a number of instances. In this way it was possible to get complete series of photographs of the two first sibships of the third generation and their parents (Frontispiece and Figure 1). From one of these sibships it was also possible to get a complete series of hair samples, which is particularly instructive (Figure 2).

The distribution of woolly hair in this family offers a perfect illustration of regular dominant inheritance. It corroborates the analogous findings of Bell (Gossage), Mori, Van Bemmelen, Kranz, and Mohr. The proportion of affected to normal in our pedigree is 13:17. No case of skipping a generation was found. The proportion of affected men to affected women is 8:7, which likewise agrees with the findings of other authors. No carrier of the trait has yet been found; and the sexes are equally represented in the inheritance of this trait. The ratio of affected to normal in all the cases reported, put together, is 138: 125, thus revealing the expected excess of affected persons, statistically. The table below shows these relationships.

The woolly hair in all the affected members of our pedigree chart is, as shown by Frontis. and Fig. 1, abnormally short and thick,—it is like real wool. The differences in length among

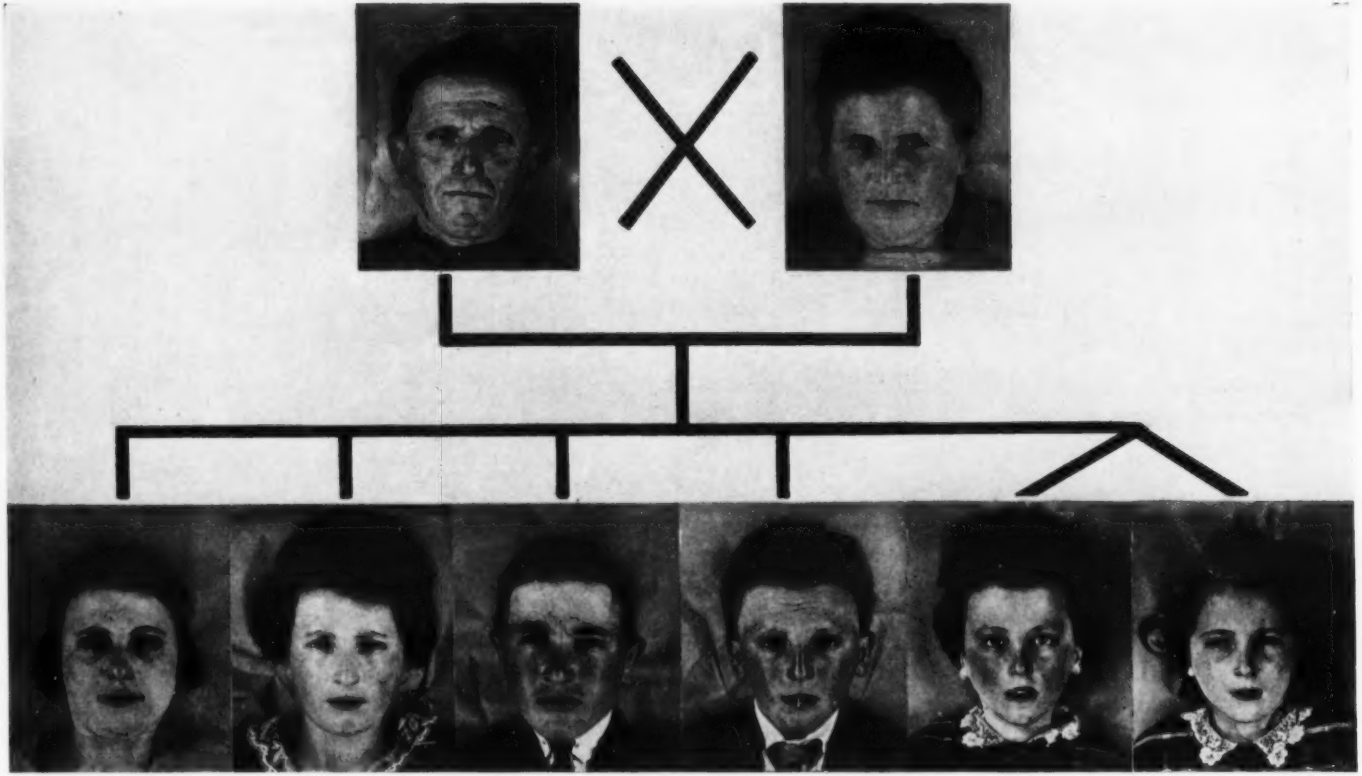
TABLE I.—Ratios of woolly haired individuals to normals in all cases reported.

Authority	All Persons Studied		Affected Persons Only		
	Affected	Normal	Males	Females	Sex Not Stated
Bell (after Gossage)	18	18	2	5	11
Mori	38	28	23	16	
V. Bemmelen†					
Kranz	28	19	15	10	4
Mohr	41‡	43	14	25	
Schokking	13	17	8	7	
	138	125	62	63	15

*This is a study from the dermatological clinic and polyclinic (Prof. Dr. H. W. Siemens, director) of the royal University of Leiden, in which Dr. Schokking was formerly first assistant. The translation is by Paul Popenoe.

†Not given in such a way that the actual proportions can be calculated.

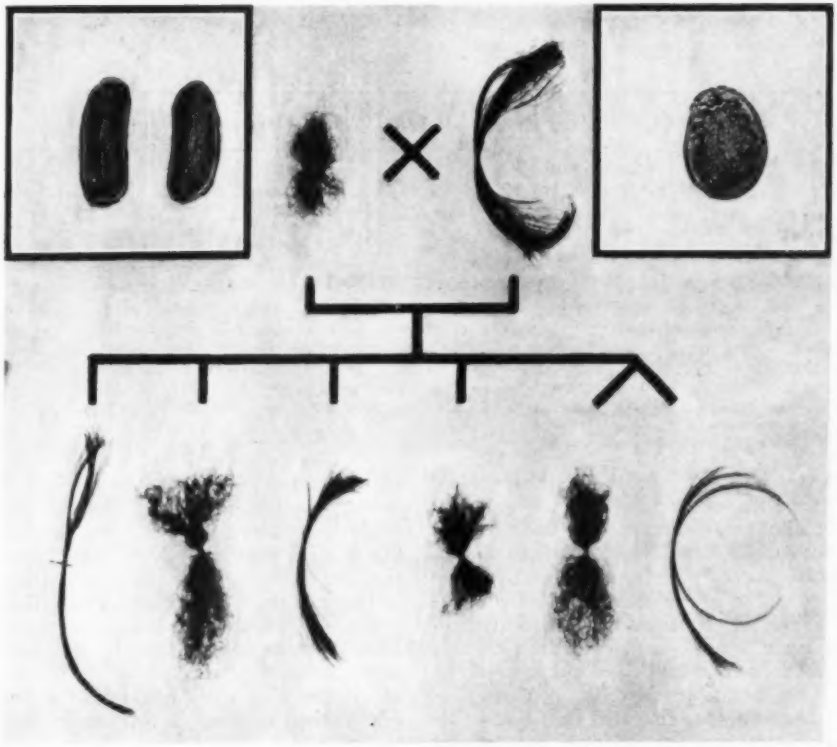
‡Three of these are said only to be "probably" affected.



FIFTY-FIFTY SEGREGATION IN HAIR FORM

Figure 1

Figure 3 gives the ancestry of this family for five generations. These children's grandmother also had straight hair and it follows that their father can carry only one gene for woolly hair, since he inherited from his mother a gene for straight hair. The theoretical expectation of a progeny half woolly haired and half normal haired is exactly realized in his six children. The twins, who are the youngest members of the family, differ in hair form and in hair color. They are evidently not identical.



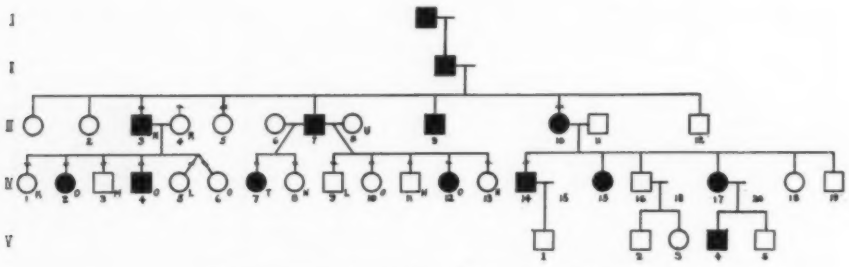
A HAIR PEDIGREE CHART

Figure 2

This is a pedigree chart of hair samples of the family shown on the opposite page. In the upper corners of the illustration are enlarged cross sections of the two types of hair taken from two of the children in this family. The straight hair is roughly circular in cross section while the woolly is eliptical in cross section, with occasional thin places. At these constrictions the hair breaks off spontaneously so that it never reaches any great length.

the various persons are considerable, whereas there are no important differences in the degree of wooliness. Evidently, therefore, one can not suspect here the working of two factors, such as Eugen Fischer has found in the crossing of woolly haired with smooth haired races in general. The segregation ratio found here indicates, therefore, that the Rijnsburg woolly hair was not brought into Holland through racial intermarriage, but that it is of independent and local origin.

The color of the hair was various among the woolly-haired persons. Mohr has remarked that there is no "absolute correlation" between hair-form and color; we must go much further in this case, and say that in our pedigree chart there is no correlation at all between form and color of hair. This is evident from a study of Figure 3, where the hair color has been indicated in each case by the use of the



FIVE GENERATIONS OF WOOLLY HAIR

Figure 3

Pedigree chart showing relationship of the two groups shown in the preceding illustrations. Many of the living members of this family were seen by the author and these individuals are indicated by the double cross hatching on the stem of the symbol designating them. There is no correlation between hair color and hair form, as is indicated by the Fischer-Saller hair color indices (the small capital letters to the right of some of the symbols).

letters adopted in the Fischer-Sailer hair-color-chart.

The cross-section of the hair, on the other hand, is closely correlated with the hair form, since normal hair is a round in cross-section while woolly hair is elliptical. This is shown in Figure 2 by the cross-sections of hair of the second and third children of the IV generation. Microscopical examination further revealed that the woolly hairs are not uniform throughout their length, but have thin places here and there as a result of the twisting; or perhaps the statement would be more accurate if reversed, that they are curled because of the presence of thin places here and there. The ends of the woolly hairs were split up into several bundles of fibres, but I could not confirm the observation of Mohr that the peripheral bundles of fibres are longer than that in the center.

There is no evidence as to how this gene for woolly hair came into the Dutch peasant family. It is certainly most unlikely that it derives from a racial crossing with Negro, for in no one of the members of the family was the slightest trace of any other character of a colored race to be found. Moreover, there is no family tradition as to any foreign racial intermixture. We must suppose that this gene represents a mutation on European soil, as Mohr and Eugen Fischer have suspected in similar cases.

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CONGENITAL TREMOR IN YOUNG CHICKS

F. B. HUTT* and G. P. CHILD
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IN THE hatching season of 1929 there appeared among some pedigreed S. C. White Leghorn chicks two from the same hen—H287—which were affected with a very evident tremor. These died within a week after hatching. The fact that H287 was mated to a closely related male suggested that there might be a genetic basis for the abnormality. This was confirmed in 1930 when four more chicks were obtained from H287 and related stock. Accordingly an attempt was made to determine the genes involved in its inheritance.

Description

Affected chicks exhibit all degrees of tremor from an agitation so extreme that the animal cannot stand, down to a barely perceptible tremor. In nearly every case, however, the tremor is evident only when the chicks are standing and is quite imperceptible when they squat. In a few of the more extreme cases some twitching was evident in the squatting bird but such instances were rare. This method of finding relief from their peculiar affliction was quickly learned by the chicks and those with tremor were usually quite easily detected in the brooder by their habit of squatting when not actually feeding or drinking.

Contrary to the situation in some cases of involuntary muscular movements in other species, the tremor observed in these chicks is not induced by sudden shock nor is it noticeably increased by excitement. When the chick is standing, the attack is not spasmodic, but continuous.

In some instances affected chicks were not recognized as such when removed from pedigree bags or baskets, but showed the abnormality distinctly after they were placed in the brooders. Apparently while they were closely confined or crowded, with little or no opportunity to use their legs, the symptoms had no opportunity to be manifested. In other cases some chicks which appeared to have a slight tremor when banded shortly after hatching showed no sign whatever of the condition when re-examined a day later. The majority of these had apparently merely been shivering from the temporary chilling suffered when they were removed from the brooder, but the possibility cannot be excluded that some of the birds genotypically "tremblers" were so slightly affected that they could not be recognized.

Some of the chicks affected with tremor have the toes curled underneath and apparently partially paralyzed. This led to the designation of the character in an earlier brief report of this condition (Hutt[3]) as "congenital palsy." It is now clear, however, that many of the less extremely affected birds have no sign of paralysis and accordingly the term tremor is the correct one.

In the few trembling chicks that survived longer than a week, the tremor became less and less noticeable. After eight weeks of age there was no sign of the tremor, although all but two of such chicks were markedly stunted. The anatomical or physiological defect responsible for the character has not yet been discovered.

Rate of Vibration

Some idea of the rapidity of movement in these chicks is indicated in Figure 4*A*. The five birds shown are

*Now at Cornell University, Ithaca, N. Y. This is the third of a series of papers by the senior author prepared under the general title: "Genetics of the Fowl."

†Paper No. 1284 of the Journal Series of the Minnesota Agricultural Experiment Station. The investigation was supported by a grant from the Fluid Research Funds of the Graduate School of the University of Minnesota.

all siblings of exactly the same age—three days. The time of the exposure, which was made with a flash bulb, was only one-fiftieth of a second. This was short enough to ensure sharp images of the four normal chicks at the right, but the one at the left was shaking so rapidly that only its toes present an unblurred image. The two separate images at the anterior end of this chick give some idea of the distance travelled by the head in one-fiftieth of a second.

The rate of vibration has been measured more accurately with a kymograph. A string was tied around the body of the chick to be tested, just behind the wings. This was fastened to one end of a recording pencil, the other end of which touched the revolving drum of the kymograph. To prevent chilling an electric light bulb was placed near the chicks.

Owing to the fact that chicks with tremor will not stand long, but either fall, squat or move about, it was difficult to record their movements, and only short records were obtained of standing chicks. Typical examples are shown in Figure 5, *A* and *B*. Figure 5*A* shows the movement of a two-day-old chick and Figure 5*B* shows that of the same chick at four days. In all the records shown, the smoked paper on the kymograph drum was revolving at the rate of 1.026 centimeters per second. The average number of complete (double) vibrations for this chick at two days and four days was 7.3 and 6.2 respectively per second.

Figure 5*C* shows the record of a day-old chick with tremor whose head was supported. The number of vibrations per second was 10, but, owing to the support provided, the amplitude of the vibration was comparatively small. Figure 5*D* shows the record of this same chick when squatting. The undulations represent breathing movements and there is no sign whatever of tremor.

In Figure 5*E* is shown the record of a fifteen-day-old chick standing, which at two days was shaking at the very rapid rate of 17 vibrations per second. Any vibration remaining is practically imperceptible. The record in Figure 5*F* shows a record of breathing for a normal control chick, standing, at two days of age.

The following data on the rate of vibration at different ages show the tendency for the rate of vibration to become less as the chicks get older:

Chick	Age	Complete Vibrations per second
C1709	1	10
D2310	1	13
C1655	2	16.5
I 29	2	10
D2167	2	7.3
D2310	4	8.5
D2315	4	8.5
D2167	4	6.2
C1655	15	0

Effects on Viability

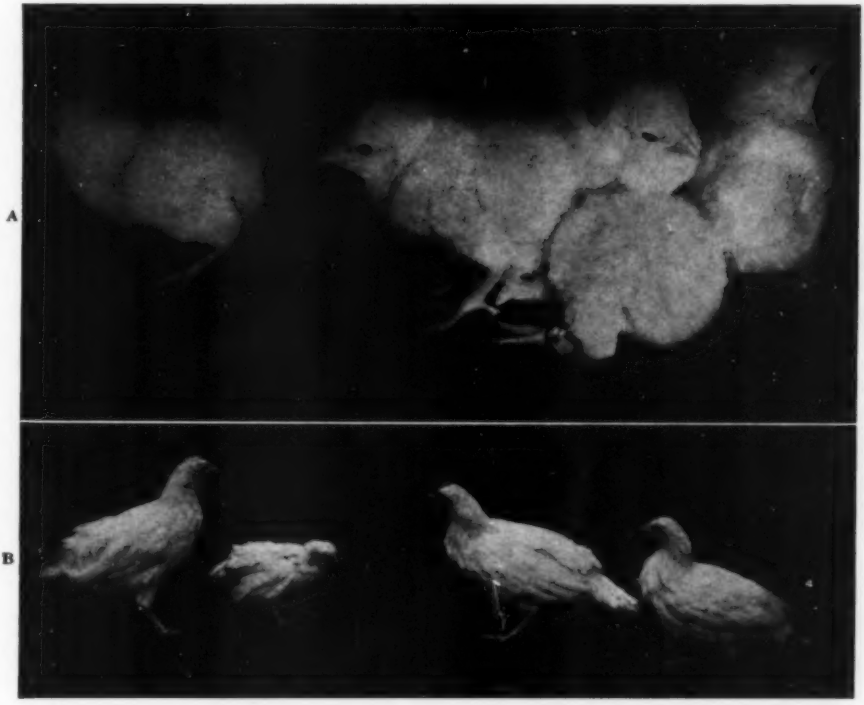
The majority of the chicks affected with the tremor die within a week after hatching. Among 35 such chicks for which exact data are available the ages at death were as follows:

1 to 7 days	24
7 to 30 days	7
30 to 90 days	2
277 days	1
Still alive at 14 months	1

These figures show that 68 per cent of the affected chicks died within a week and 88 per cent within a month after hatching. To some extent the early mortality resulted from the inability of extremely affected chicks to move about freely and to find feed and water. Others literally shook themselves away from the heat and got chilled. But even some which were kept in extremely favorable conditions, where it was difficult for them to get chilled and where feed was easily accessible, grew very slowly and soon died.

Effects on Growth

In Figure 6 the growth rates of four chicks with tremor are compared with those for their normal siblings. One of the four died at two weeks of age, but it is obvious that growth in the others was greatly retarded. Except for two birds with tremor which lived to over nine months of age, the three whose



A TREMBLING CHICK AND NORMAL SIBLINGS

Figure 4

Five siblings from a tremor-producing hen. The exposure, one-fiftieth of a second, was short enough to result in sharp images for the four normal chicks on the right, but not short enough to catch the chick on the left, which was affected with congenital tremor. In the lower photograph are shown four of the five chicks photographed again at 51 days. The chick which originally had tremor weighed, when this photograph was taken, about one-third as much as her normal sister on the right. Her retarded growth has resulted in an abnormal bulging of the cranium.

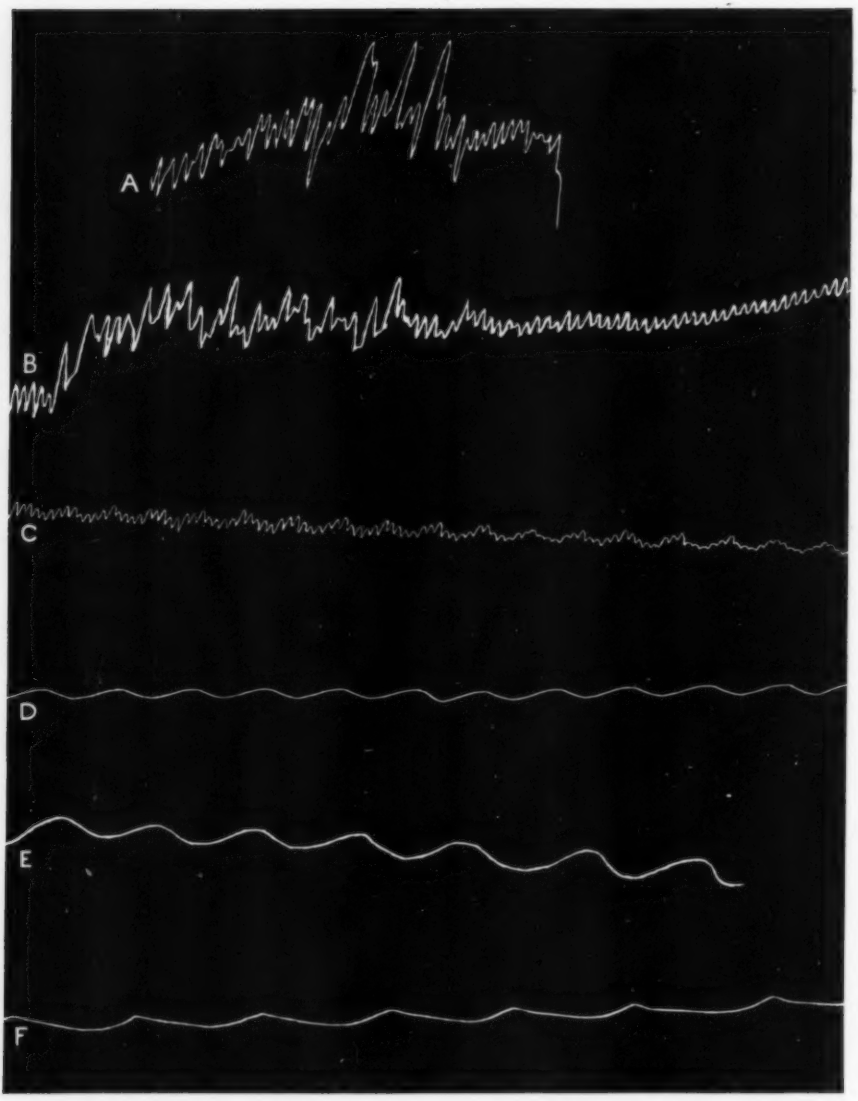
growth curves are shown were the most vigorous of all the chicks with tremor.

The effect of the character is more strikingly shown in Figure 4*B*. The four chickens illustrated were all hatched from the same hen on March 30, 1932. At the time of the photograph they were 51 days old. Their weights, reading from left to right, were as follows:

Bird	Weight in grams at 2 days	Weight in grams at 51 days
♂ B2104 (normal)	34	314
♀ B2101 (tremor)	31	103
♂ B2103 (normal)	33	387
♀ B2102 (normal)	32	299

The chick with tremor, second from the left, shows the bulging of the cranium so commonly seen in stunted and dwarf chicks. This malformation was evident in nearly every chick with tremor that survived beyond a month. It is attributed, not to any direct effect of the gene for tremor, but rather to the retardation of growth induced by that gene.

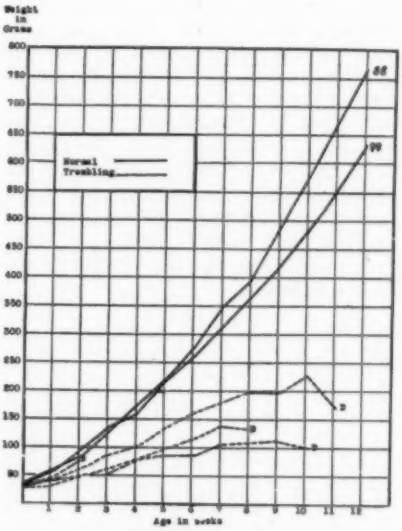
Of the two chicks with tremor which survived longer than three months, one attained a maximum weight of 1,029 grams at 30 weeks, the other grew to 1,375 grams at 40



GRAPHIC CONTRAST BETWEEN TREMBLING AND NORMAL CHICKS

Figure 5

Kymograph records of chicks with tremor (*A-E*), and of a normal chick (*F*). *A*—Record of a chick with tremor two days old, standing without support. *B*—Same chick as above four days, standing. *C*—Tremor, one day, partially supported, and *D*—same chick as in *C*, squatting. *E*—Chick with tremor fifteen days old, standing. *F*—Normal control two days old, standing. The tremor is most marked in the very young chicks and becomes less as the chicks grow older. The regular pulsations of the lower three records (*D-F*) are due to breathing, and are not the result of tremor. The disappearance of tremor does not restore the vigor of the "tremblers," for most of those that survive the first week die within a month.



GROWTH RATE OF TREMBLING CHICKS

Figure 6

Growth rate of four chicks with tremor as compared with their normal siblings. The chicks in this brood were among the most vigorous of the chicks showing this condition. Their extremely slow growth rate emphasizes the semi-lethal nature of this variation. Only two "tremblers" have reached maturity.

weeks. The latter figure is somewhat below the weight for normal Leghorn females of that age in the stock from which the bird was raised. The former weight is decidedly sub-normal. Since these two chicks were hatched on April 13th and May 4th, their failure to attain normal weight cannot be attributed to their having been raised out of the normal growing season.

Effect on Reproduction

The smaller of the two birds just mentioned died at 277 days, without ever having laid an egg. The larger one laid her first egg at 239 days of age. The average age at first egg for eight other White Leghorn pullets hatched on the same day as this bird, and, like her, from matings disregarding fecundity, was 191 days. Only one of these eight began laying at a later age—246 days.

Up to 413 days of age, this bird had laid only 35 eggs, but since a number of her less productive pen-mates had been disposed of, there are not adequate controls against which to compare her record. However from the fact that her monthly egg records from December to May were 9, 2, 5, 5, 4, and 10, it is obvious that she was far below normal with respect to fecundity. Of 22 eggs set between December 15th and May 15th, 15 were fertile and these yielded 7 chicks, a proportion which is not unusually low.

Genetics

The genetic analysis of this character has been extremely difficult to conduct. Since affected chicks (with one exception) did not attain sexual maturity, the usual methods—studying an F_1, F_2 and backcross—were out of the question. Any genetic analysis had therefore to be based solely on the observed ratios in matings yielding congenital tremor. These were as follows:

	Chicks	
A—Dams	Normal	Tremor
H 287	19	2
K 167	15	1
K 196	36	3
K 219	20	1
L 152	10	1
A 155	11	1
A 525	12	2
B 121	7	1
B2010	7	2
B2033	6	1
B2024	19	2
B2047	50	5
B2053	20	2
B2058	48	3
B2062	18	1
B2065	24	1
B2067	18	2
C2004	4	1
C2005	12	2
C2006	19	1
C2007	1	1
C2008	5	2
C2078	27	1
Total	408	39
Ratio	10.5: 1	

B—Sires (in matings with hens that produced tremor)		
L 2	33	2
L 7	65	6
A1021	6	1
A1024	6	1
B2232	28	7
B2233	107	9
B2241	1	1
B2243	13	2
B2244	85	6
C2221	60	3
C2222	4	1
	408	39

It should be clearly understood that these ratios are for matings in which both male and female were proven producers of congenital tremor. Fowls yielding chicks with this affliction are apparently normal in every respect and the character is therefore recessive in nature. The ratios given above, however, are far from the 3:1 expected for a unifactorial recessive. In some cases where a single chick with tremor was obtained in a progeny of eighteen chicks or more, it was at first believed that there must have been some error in marking the egg or in recording the chick. However, there are at least five such cases in the list of 23 females above. These occurred in different hatching seasons and in different matings. It seems improbable, therefore, that these aberrant ratios can be ascribed to errors in technique. Indeed, the rarity of the character would suggest that it is not genetic in origin were it not that (1) chicks with congenital tremor occurred originally in a mating of closely related stock (2) they have not been observed in other White Leghorns or in other breeds of the university poultry flocks during the six years in which the character has been observed, and (3) in twenty-five years' experience with poultry the senior author has never seen chicks elsewhere similarly afflicted. Moreover, other females in the same pens and mated to the same males as those yielding chicks with tremor did not produce the character in progenies ranging up to thirty. It is also pertinent that in progenies from matings in which both sire and dam produced tremor, or had done so, the ratio of normal chicks to those with tremor was remarkably constant in the four years in which complete data were available. The figures for these are as follows:

	Chicks		
Year	Normal	Tremor	Ratio
1931	80	7	11.4:1
1932	64	7	9.1:1
1933	164	16	10.2:1
1934	94	9	10.4:1

The fact that practically all of the affected chicks died shortly after hatching suggested that the character might be sufficiently disadvantageous to the embryo to cause death in enough of them to account for the observed deficiency of chicks with tremor. This possibility seemed all the more plausible because several chicks with tremor occurred among those which had to be assisted from the shell at hatching time. More extensive data have shown this hypothesis to be untenable. The figures given below compare the rates of embryonic mortality among embryos from *a*, matings in which both sire and dam were known to be tremor-producers, and *b*, matings in which the sire was a producer of tremor but the individual females did not yield the character in eight or more chicks.*

The difference between mortality rates in these two types of matings is neither statistically significant nor large enough to account for a deficiency of chicks with tremor as great as that observed. With the evidence established that embryonic

*Embryonic mortality rate.

	Fertile eggs	Mortality	
		Number	Per cent
(a) Matings yielding tremor	572	241	42.13 ± 2.06
(b) Females not producing tremor	773	295	38.16 ± 1.74
Difference			3.97 ± 2.69

mortality was not responsible for any aberrant ratios in hatched chicks, an explanation of the observed ratios of normal chicks to those with tremor may be attempted.

If the character were sex-linked as well as recessive, one would expect it to occur more often in females (the heterogametic sex) than in males. Since in 35 affected chicks of known sex the ratio was 19 ♂♂ : 16 ♀♀, it is obvious that the character is autosomal.

There are two interpretations of the available data on the genetic basis for this character which seem possible. It may be the result of duplicate factors, with affected chicks homozygous for the recessive allelomorph of each. If these genes be designated T and T_1, the expectation in the progeny from a mating of two diheterozygotes, $Tt\ T_1t_1$, is 15 normal chicks to 1 with tremor. The observed ratio in the general population, as given above, is 10.5 to 1. This, however, does not by itself invalidate the duplicate factor hypothesis because that population contains several females with affected chicks in progenies of much less than 16. Presumably there could be a corresponding number of undiscovered females producing no chicks with tremor in progenies of less than 16, but which would have produced the character in larger families above that figure. Examples of this type are afforded by females K219, B2062, B2065, C2006 and C2078, each of which yielded only one chick with tremor in progenies of 20, 18, 24, 19 and 27 respectively.

If one considers that progenies of at least 16 are necessary for the manifestation of a 15:1 ratio and selects only the thirteen hens with families of that size or over, the ratio of normal chicks to those with tremor is as follows:

	Normal	Tremor
In families of 16 or over	330	25
Expected (15:1)	332.8	22.2

This is a very close fit to expectation. A corollary to the duplicate factor hypothesis is that some of the birds in the population must be by chance of the constitution Ttt_1t_1 or ttT_1t_1 and that these when mated together would give a ratio of 3 normal: 1 tremor. If mated to a diheterozygote, TtT_1t_1, they should yield a ratio of 7:1. In the list of ratios given above it may be noted that the following progenies suggest a 3:1 ratio:

	Chicks	
Dam	Normal	Tremor
B2010	7	2
C2004	4	1
C2007	1	1
C2008	5	2
	17	6

There are also in the list several progenies suggesting 7:1 ratios more than anything else, but some of these may also really belong in the 15:1 class. Unfortunately no 3:1 ratios occur in large progenies, so that it cannot be definitely stated that any mating was yielding a 3:1 ratio.

The duplicate factor hypothesis could be substantiated or disproved if a large number of daughters from tremor-producing matings could be adequately tested. Such a test has been practically impossible in this case because the usual difficulty of getting large progenies from individual hens has been aggravated by the fact that the mutation originally appeared among fowls of rather low fecundity. Their naturally poor reproductive capacity has been anything but improved by the inbreeding resorted to in the attempt to study the character. Some of the tremor-producers died after producing only five or six chicks or less. Others were not detected until the second breeding season. The difficulty of testing either males or females when such large progenies are needed to prove the genotype is obvious.

Tests of genotype were attempted with 65 daughters of birds which had

produced tremor. Of this number 24 had a carrier of tremor in both parents and 41 had only one parent producing the character. Owing to mortality and low production more than half of these birds were not adequately tested, but the following data are of interest:

	No tremor in 6 or more chicks	Produced tremor
Birds with both parents carriers	7	7
Birds with one parent carrier	16	3

While 6 chicks are undoubtedly too few to constitute an adequate test, the limitations of that number should apply equally to the two groups compared. On this basis, when both sire and dam were carriers, 50 per cent of the progeny were also carriers, but when only one parent had produced the character, only 16 per cent of the progeny were carriers. The comparison illustrates the hereditary nature of the character even though it does not elucidate the genetic basis.

Another possibility is that congenital tremor may be a unifactorial recessive, but one so subject to the influence of modifying genes that the degree of its manifestation, or its "penetrance" (in the sense of Timoféeff-Ressovsky), is unusually low in most matings. This is suggested partly by the fact that in moderate cases the tremor becomes less extreme within a week of hatching and eventually disappears as the chick gets older. It is also suggested by the occasional chicks from tremor matings, which display a very slight shiver when taken from the incubator. These are difficult to classify, but, because they have not subsequently shown any signs of tremor, have been considered as merely chilled at banding time.

This hypothesis is supported by the fact that the one bird with tremor which produced offspring yielded in matings with males carrying congenital tremor no chicks with tremor among the seven which were hatched from her. Three of these seven, however, had their toes curled under and apparently slightly paralyzed or incapacitated when hatched. This peculiarity was not evident a day or two later, when the chicks appeared normal in every respect. It seems not improbable that the same defect, which causes the agitation when the chick is standing, but which is inoperative (except in extreme cases) when the chick squats, might be also manifested as a temporary partial paralysis of the extremities of the legs. As chicks so affected get older, both symptoms disappear. The latter interpretation appears somewhat more likely than that of duplicate factors only.

The observed number of chicks with tremor in the whole population of 447 was 39. The expected number for a simple recessive with complete penetrance was 111.75. The actual penetrance (*i. e.*, percentage of those homozygous for the character which actually manifest the phenotype) was therefore 35 per cent, although marked deviations from that figure were evident in individual matings. This is a rather low degree of penetrance, but that fact does not rule out the probability that the character is caused by one gene. Among several genes producing the character "abnormal abdomen" in *Drosophila funebris*, Timoféeff-Ressovsky[7] found some with a penetrance of 20 to 30 per cent and one with a penetrance of only 10 to 15 per cent.

Discussion

Congenital tremor in chicks is evidently a hereditary character undesirable both to the species and to the poultryman. Since it is so subject to the influence of modifying factors that it may appear as infrequently as once in 27 chicks from one mating, the usual methods of testing for carriers would not be efficient. Accordingly, there is no other method of weeding out the character than to

eliminate from the breeding pens all sires, dams, and siblings of affected chicks. Even this would not remove all heterozygotes, but it is doubtful if the loss from the few affected chicks would warrant any greater sacrifice of breeding stock.

The tremor described in this paper is apparently quite different from the hereditary ataxia observed in pigeons by Riddle,[6] nor is it at all comparable to the "congenital loco" studied by Knowlton,[5] a condition which is fairly common in chicks. In neither of these abnormalities does one find the consistent vibration of the whole body which was characteristic of the chicks affected with tremor. It is apparently quite similar in some respects to the hereditary tremor which occurs, though rarely, in man. The pedigree of this reported by Bergman[1] suggests dominance of the condition. Moreover, in his cases and others, the tremor was not apparent at birth, but, contrary to the condition in chicks, became progressively worse after onset at ages of 30 and over. Curschmann,[2] however, states that in some cases of hereditary tremor in man the symptoms may entirely disappear as the affected person gets older. In Bergman's cases the rates of vibration were very much like those measured in the writers' chicks and in both species the tremor disappeared when the afflicted subject was at rest.

Of all the cases of hereditary nervous disorders in other species with which the congenital tremor in chicks has been compared none resembles it as much as the recessive hereditary trembling in guinea pigs, briefly reported by Ibsen.[4] In both species there is a tremor right from birth and in both it becomes less extreme as the animals get older. He does not say if the symptoms are absent when the affected animal is at rest.

It seems not impossible that mutations such as the tremor described in this paper, though undesirable in most respects, might be of value to pathologists seeking to determine the anatomical or physiological bases for similar hereditary diseases in man. The aetiology of hereditary tremor (as distinguished from various ataxias, choreas and *paralysis agitans*) is apparently not known. If principles of human nutrition can be learned from studies with rats and pigeons, it seems equally feasible that genetic abnormalities in lower animals could be utilized to shed some light upon similar conditions in man.

Summary

Chicks affected with congenital tremor exhibit degrees of agitation varying from a shaking so extreme that they cannot stand, down to a barely perceptible tremor. In most cases this movement disappears when the chick squats at rest. The rate of tremor varies from 16.5 to 10 complete (double) vibrations per second in chicks one and two days old. The affliction is most extreme at hatching and gradually disappears in the few chicks which survive to a month or more.

Eighty-eight per cent of affected chicks died within a month of hatching and only one out of 35 was raised to sexual maturity.

Growth of chicks with tremor was greatly retarded and fecundity was unusually low in the one bird raised to laying age.

Twenty-three fowls producing the defect yielded in matings to carrier males a total of 408 normal chicks and 39 with tremor. The deficiency of affected chicks below the number expected for a simple recessive character is shown not to be caused by embryonic mortality in these matings.

Of 35 affected chicks 19 were males and 16 females.

A duplicate-factor genetic basis is shown to account for the observed ratios fairly well, but it is considered a more likely interpretation that the character is a simple autosomal

recessive character having an unusually low degree of penetrance because of the effects of modifying genes.

Other evidence is adduced to show that the defect is definitely hereditary.

The similarities and differences between hereditary tremor in the fowl and similar conditions in other species are briefly considered.

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✦

Arguments for Sterilization

THE text of this book* which is concerned with the prevention of hereditary disorders, begins with a long introduction comprising some fifty pages wherein hereditary principles and theories are discussed, and illustrated by many diagrams, heredity charts, and case histories. Following the introductory parts, the fundamentals of a sterilization law are presented.

Many arguments in favor of, and reasons for sterilization are given in detail. Among these are the usual statements covering the economic and social situations. It is emphasized that it is not only the retrogression in the number of the people that occasions the gravest concern at present in Germany, but in like measure the condition of the hereditary constitution of the people. While the hereditarily healthy families have for the greater part joined the one or no child system, numberless inferior and hereditarily burdened people continue to bring forth children in large numbers, whose diseased and antisocial condition becomes a burden to the whole nation, without any check. While the healthy German families, especially in the educated classes have on the average only two children, weak minded, and other hereditarily lower conditioned families show three or four children each. Under such conditions the composition of a people changes from generation to generation so that in perhaps three generations the normal class is entirely overgrown by the incompetent. This means the dying out of highly valuable families, and thus an important matter is at stake; the future of the people is endangered.

There is a section with colored plates by Lexer on the anatomical and physiological relationships and the surgical technique of sterilization of males, and a similar one on sterilization of females by Döderlein. The book is excellently amplified by glossaries, an extensive classified bibliography and a serviceable index. As a whole it contains a wealth of information on human heredity.

N. D. C. Lewis

St. Elizabeth's Hospital

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RECUMBENCE IN WHEAT

As Influenced by Light and the Soil Surface

H. H. McKinney and W. J. Sando*

That environmental factors do affect the expression of genetic characters is a truism, but our knowledge of the reactions between any specific environmental factor and the gene-complex of a given plant is still fragmentary. Merely by removing the soil surface the authors have brought to light significant varietal differences in recumbence (allegedly a qualitative character) which could not appear in field culture. These observations, and others elsewhere recorded, suggest that the period covered by the *Bibliography of Plant Genetics* reviewed in this issue may come to be recognized as really the "juvenile stage" of plant genetics. Were we to hazard a guess regarding the direction which "adolescent" and "adult" development would take we might speculate on what might be discovered in the still largely untilled field between genetics and physiology (as these two really closely related disciplines are commonly defined). Such coordinated studies of the genic and environmental influences on plant characters hold the key to a clear understanding of the processes whereby the genes *and* the environment cooperate to produce that amazing end product the living organism,—about which there is still so much we do not know.—Editor.

RECUMBENCE and erectness are characters long recognized in wheat[2] and it has been known that certain varieties are intermediate or semi-recumbent.[2, 6] Recumbence and erectness have been considered to be qualitative characters not influenced by the environment,[6] but other studies[4] indicate that Turkey wheat may be recumbent or nearly erect depending on the length of the daily photoperiod. The present studies show that recumbence is influenced not only by the photoperiod, but also by other light factors, thus placing it in the quantitative group. By reducing the influence of the horizontal surface of the soil it becomes evident that the prostrate position does not represent the extreme degree of downward bending of the tillers in wheat, since in the variety Rudy the tillers bend far below the horizontal position if they are not prevented from doing so by contact with the surface of the soil.

While the studies presented here are not genetic in a strict sense, they are indirectly, as they tend to clarify our understanding of the characters under consideration. Plant geneticists generally recognize that the environment influences the expression of certain characters, but the fact remains that this knowledge is limited to relatively few characters in a few species, and it is very vague for the vast majority of characters. The value of more specific information on this subject can scarcely be doubted. It is hardly reasonable to believe that without it the geneticist can hope to obtain exact information on the inheritance of many plant characters.

Experimental Methods

Plants were grown in soil in earthen pots except when otherwise noted and the soil moisture was kept practically uniform in all parts of a given experiment. Mazda "C" tungsten lamps were used when artificial light was employed. The influence of glass was determined by growing the plants in glass chambers. The daily photoperiods were studied in similar chambers but in certain instances there was no glass on the frames. Temperatures in the chambers were equalized very closely with those in open frames by means of fans.

When the side shoots (tillers) of wheat are flat on the ground they are said to be prostrate, procumbent,

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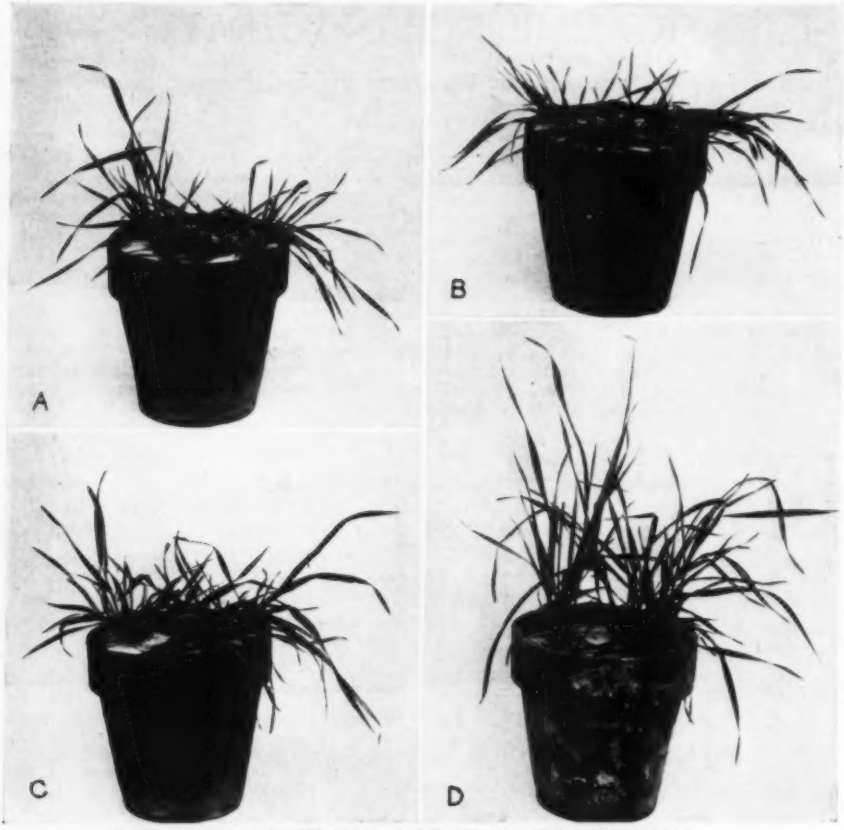


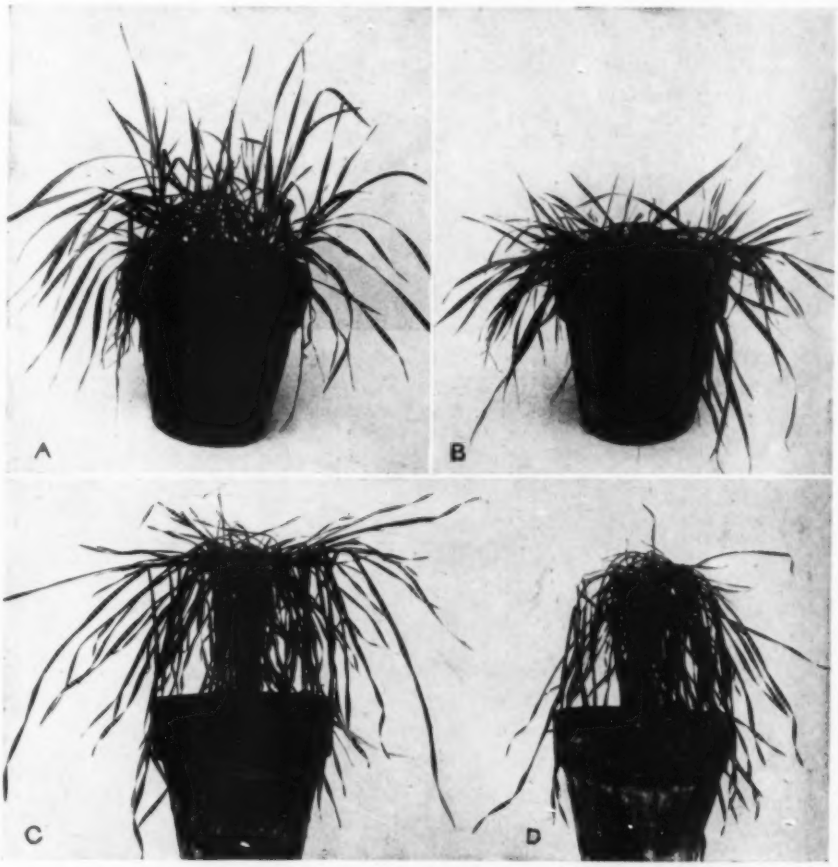
EFFECTS OF LENGTH OF DAY ON RECUMBENCE

Figure 7

Marquis and Harvest Queen wheat plants 39 days old. Marquis is located at the left in each pot. Grown outdoors in unobstructed daylight with a full sun during the summer of 1930: *A*, 6 hours daylight daily. *B*, 8 hours daylight daily. *C*, 15 hours daylight daily. *D*, 15 hours light daily made up of 8 hours daylight with 7 hours from a tungsten lamp. It is evident that the 8-hour day produces the greatest recumbence, with a tendency toward more upright growth when the photoperiod is shorter or longer, and that recumbence is reduced when the tungsten lamp is used.

decumbent or recumbent. The term recumbent indicates a leaning or a prone position, and since wheat tillers bend in different degrees this term seems to be the most suitable except that the tillers of some varieties will bend below the horizontal if given the opportunity, thus giving rise to a sub-recumbent condition. This being the case it might be more appropriate to refer to the character in question as "tiller bending." However, the term recumbent seems adequate as it covers the situation under ordinary field conditions.

In these studies the writers do not use the term semi-erect or semi-recumbent. The term recumbent is used to denote the degree of the bending (divergence) of the tillers away from the vertical axis. Crowding of tillers in the crown of the plant will cause di-



VARIETAL DIFFERENCES IN REACTION TO LENGTH OF DAY

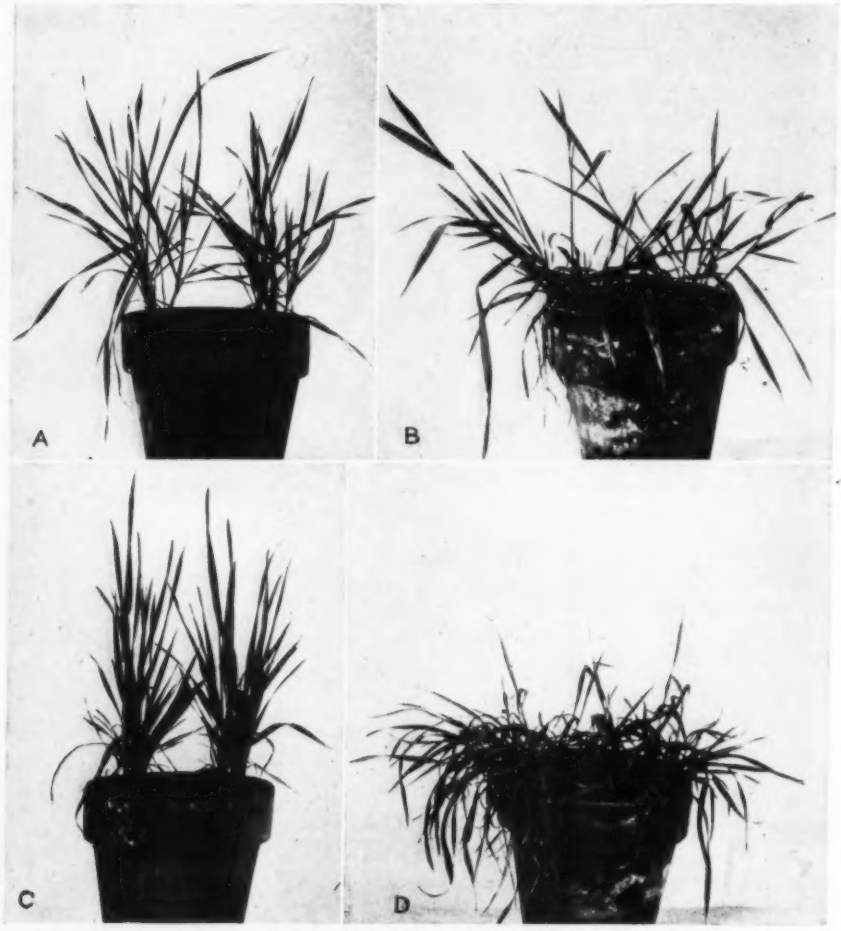
Figure 8

A, Harvest Queen winter wheat grown with a daily photoperiod of 15 hours composed of 8 hours sunlight and 7 hours of light from a tungsten lamp. Grown outdoors during midsummer. *B*, Harvest Queen plants grown exactly as *A* except that the plants in *B* were given 15 hours of sunlight daily for four days before the plants were photographed. The additional sunlight induced an extremely recumbent condition very quickly. Previous to this four-day exposure these plants looked exactly like those in *A*.

C-D. Rudy winter wheat grown at 50-70° F. in a greenhouse during the winter. The plants were separated from the soil line of the pots by means of long glass tubes filled with soil and connecting with the soil in the pots. *C*, Plant received a daily photoperiod of 11-12 hours. *D*, Plant received a daily photoperiod of 8 hours.

vergence from the vertical as much as 5-10 degrees without any bending of the tillers at the soil line, therefore, plants showing not more than this degree of divergence are tentatively considered erect. The angle of recumbence was estimated, but a protractor was used from time to time to verify estimates.

In certain varieties of winter wheat such as Turkey the leaf sheaths are very short during the autumn growth



RATE OF MATURITY NOT CORRELATED WITH RECUMBENCE

Figure 9

Recumbent and erect growth habit in spring wheat when grown with a daily photoperiod of 8 hours with unobstructed midsummer sunlight. *A*, Quality and *B*, Prelude are very early whereas *C*, Barnatka and *D*, Kinney are late varieties.

period. In such plants the leaves frequently bend at the *ligule* and assume a horizontal or prostrate position on the ground. This takes place in small seedlings with but one shoot and before there is any bending of the shoot at the soil line. This condition was not used for estimating recumbence in these studies.

The term prostrate is used to denote one type of recumbence, i. e., the appressed or flat position of the tillers on the surface of the soil.

Influence of the Length of the Daily Photoperiod

Harvest Queen winter wheat and Marquis spring wheat were grown outdoors in unobstructed sunlight

during midsummer with daily photoperiods 6, 8, and 15 hours in length. The average degree of recumbence in Harvest Queen was as follows: 6 hours, 55-75 degrees; 8 hours, 60-80 degrees; 15 hours, 35-80 degrees. In Marquis it was as follows: 6 hours, 0 degrees; 8 hours, 55-75 degrees; 15 hours, 30-50 degrees. The plants are illustrated in Figure 7*A, B,* and *C*.

It is evident from this test that the daily photoperiod may be too short as well as too long for the greatest expression of recumbence.

Influence of Glass

Harvest Queen and Marquis wheats were grown in glass-covered cases and in unobstructed sunlight. Common window glass, Vitaglass, Helioglass and Corex G980A (a Corning glass) were used. All but the common window glass transmit a considerable amount of the ultra-violet portion of the spectrum, but Corex G980A transmits by far the greatest amount,[3] being a close rival of fused quartz.

With a daily photoperiod of 8 hours in unobstructed sunlight during late summer Harvest Queen was recumbent to the extent of 30-40 degrees under common window glass, and 60-80 degrees in unobstructed sunlight. Under the same conditions Marquis was recumbent to the extent of 20-30 degrees under common window glass and 60-80 degrees in unobstructed sunlight. It will be noted that Marquis was just as recumbent as Harvest Queen in the unobstructed sunlight. However, Marquis remained recumbent for a shorter time than Harvest Queen.

When compared under Vitaglass, Helio-glass and common window glass in a full summer day Harvest Queen wheat showed no measurable differences in recumbence, but under Corex G980A recumbence averaged 50 degrees in contrast with 20 degrees under common window glass, and 55 degrees in unobstructed sunlight.

Influence of Tungsten Light

Harvest Queen and Marquis wheats were compared in midsummer with a daily photoperiod of 15 hours. One series received direct sunlight only and the other received 8 hours of direct sunlight and 7 hours light from a tungsten electric bulb (Mazda "C") which delivered 8-10 foot candles at the soil line.

In Harvest Queen recumbence was 35-80 degrees in sunlight, and 25-40 degrees when the tungsten lamp was used. In Marquis recumbence was 30-50 degrees in sunlight, and 0 degrees when the electric lamp was used. The plants are illustrated in Figures 7*C* and *D*.

Part of the Harvest Queen plants receiving sunlight and electric light were shifted to full sunlight with no change in the length of the photoperiod. Within four days the plants were nearly prostrate as shown in Figure 8*B*, thus showing the profound influence of bright sunlight on the degree of recumbence.

Influence of Shade

Harvest Queen wheat was grown in summer sunlight with and without shade. Shade was provided by means of a single bleached cheesecloth with 44 meshes to the inch. Recumbence was 30 degrees in the unobstructed sunlight and 0 degrees in the shade, indicating that light intensity also is a factor influencing the expression of recumbence.

Influence of the Horizontal Soil Surface on the Bending of the Tillers

A number of varieties of winter wheat were sown in the spring in the field nursery and it was observed that 8 selections of Turkey and one of Rudy became prostrate just as they did in the autumn-sown nursery, whereas many other winter varieties were not quite prostrate in the spring nursery, but were prostrate in the autumn nursery.

As the summer season advanced the plants in the spring nursery became more erect, but Rudy was noticeably tardy and remained complete-

ly prostrate until June 1 when the tillers showed signs of rising.

These observations together with observations on some of the prostrate wild grasses suggested that the tillers of some varieties would bend below the horizontal if the influence of the soil surface were eliminated. Accordingly Rudy wheat was planted in long narrow tubes of soil placed in pots of soil as shown in Figure 8*C-D*.

The illustration in Figure 8*D* clearly shows that the surface of the soil as in plats or pots will prevent the extreme bending of the tillers in some varieties. Many of the tillers in Figure 8*D* assume a position 180 degrees from the vertical position.

Tests with Spring Varieties

A group of early, midseason, and late spring varieties was tested outdoors during the summer with a daily photoperiod of 8 hours. Data on recumbence are given in Table I. Recumbence was expressed to a greater or less degree by all varieties but Barnatka. In ordinary nursery sowings made in the spring all of these varieties class as erect, excepting Kinney, which sometimes shows slight recumbence. When the plants are spaced in the nursery rows a slight amount of recumbence occurs in varieties showing over 50 degrees of recumbence in the 8-hour photoperiod, but it is erratic and too slight for making comparative studies.

In Baroulina's[1] classification of the soft wheats two spring varieties are listed as having prostrate seedlings. One of these, Persia, is too late to head at St. Petersburg. The other, Turkestan, apparently is not so late, but no statement is made. The writers have not observed prostrate types among spring varieties when grown in the field from spring sowing.

The data in Table I show a lack of consistent correlation between the degree of recumbence and relative earliness from spring sowing. Typical plants of four varieties are illustrated in Figure 9. Prelude, a very early variety, developed recumbence to a considerable degree, but Quality, also early, was nearly erect.

While all of the varieties listed in Table I are considered spring varieties,[2] it has been pointed out[5] that Kinney heads earlier under certain conditions when the germinated seeds are chilled near freezing for 28 days before sowing, thus suggesting that the variety has a facultative type of seasonal growth habit. At Rosslyn, Va., Kinney sometimes fails to head in the spring nursery.

Hard Federation was recumbent to the extent of 30-40 degrees when grown with an 8-hour day outdoors in midsummer, but when given the same length of day in a greenhouse during the winter[4] this variety was erect probably because of the greenhouse glass and the relatively low intensity of the light.

Table I. The degree of recumbence expressed by 21 varieties of spring wheat when grown in pots outdoors during the summer with a daily photoperiod of 8 hours, and the number of days from sowing to first heading in the spring nursery.

Variety	C. I. No.	No. of days from sowing to first heading.	Degree of recumbence with 8-hour day.
Prelude	4323	52	60-75
Quality	6157	55	20-25
Reward	6188	57	35-45
Bunyip	5125	59	20-25
Hard Federation	4950	59	50-60
Baart	1697	59	50-60
Sonora	3036	60	35-45
Haynes Bluestem	3274	63	20-25
Hope	5178	63	20-25
Kota	5878	64	50-60
Marquis	3641	65	60-75
Rink	5868	66	35-45
Barnatka	5214	69	5-10
Humpback	3490	69	35-45
Touse	6017	69	35-45
Bluechaff	5256	72	35-45
New Zealand	6011	72	20-25
Pacific Bluestem	4067	72	50-60
Sevier	6247	72	50-60
Jenkin	5177	75	50-60
Kinney	5189	80	75-90

Table II. Test illustrating the lack of correlation between the characteristic recumbence and the relative temperature requirements of the initial growth phase for the earliest subsequent heading in five winter varieties.

Variety	Temperature requirements during the initial growth period in days.*		Degree of recumbence in an 8-hour day near 60°F.
	Deg. F.	Days	
Red Winter spelt	55-72	15-25	80
Harvest Queen	45-60	35-45	50
Minhardi	45-60	35-45	50
Turkey	45-60	35-45	90
Hybrid "X"	40-45	35-45	80

*These data are based on an 8-hour daily photoperiod during the initial growth period, after which temperatures were near 70-75°F. with a daily photoperiod of 16-18 hours.

The most extreme expression of recumbence in the writers' experiments has been in winter varieties falling in the midseason group at Rosslyn, Va. All midseason varieties, however, do not express the same degree of recumbence, Harvest Queen and Turkey, e. g., both being midseason for earliness, but Harvest Queen is less recumbent than Turkey (Table II).

It has been shown[5] that winter varieties differ in their temperature requirements during the initial growth period with respect to their earliest heading when subsequently grown at high temperatures. Other tests indicate that these first-phase temperature characteristics of winter varieties are not consistently correlated with the degree of recumbence expressed by the varieties. In Table II it will be noted that the Hybrid "X" has the lowest temperature characteristic, yet it develops the least recumbence in the group. Red Winter spelt has the highest temperature characteristic, yet it is nearly as recumbent as Turkey. Harvest Queen, Minhardi and Turkey fall in the same temperature group, but they range from 50 to 90 degrees in their expression of recumbence.

Discussion and Summary

From the evidence now available it appears that recumbence is a quantitative character in wheat. The character is accentuated by bright sunlight and by short daily photoperiods near 8 hours in length. Light from Mazda "C" tungsten lamps and that transmitted through glass and cheesecloth shades reduced the degree of recumbence. Corex G980A glass favored recumbence more than any other glass tested, suggesting that recumbence is favored by the shorter wave lengths of light which are transmitted by this glass and which are not transmitted appreciably by the other glasses.

Spring wheats which are erect under ordinary culture conditions in the field in some instances develop a considerable degree of recumbence in an 8-hour day. It seems evident, therefore, that some spring wheats carry one or more genetic factors for recumbence, but which cannot be detected under the ordinary cultural conditions.

Since the horizontal surface of the soil prevents the maximum downward bending of the tillers in Rudy wheat it is evident that the extreme genotype for tiller bending cannot be obtained when plants are grown in the ordinary manner.

The several degrees of recumbence expressed by the spring varieties tested are not consistently correlated with the degree of earliness of the varieties in the spring nursery, nor were they consistently correlated with the initial low-temperature requirements for earliness in the winter wheats tested. The greatest degree of recumbence observed thus far in wheat has been observed among winter varieties which rank as midseason for earliness, though all midseason varieties are not equal in their expression of recumbence in the autumn.

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THE ORIGIN OF A SUPERIOR RED-FLESHED GRAPEFRUIT

Bud Mutation of the Thompson Variety of Possible Horticultural Value

SINCE the introduction of the Thompson (pink-fleshed, seedless) grapefruit in the Lower Rio Grande Valley there has been a demand for a variety that would possess the desirable characters of the Thompson grapefruit but would also be possessed of the attractive pink "blush" on the outside of the fruit, characteristic of the Foster variety. A constant search has been made for a grapefruit of this kind and many reports have been received about the existence of such bud varieties. However, it remained for Mr. A. E. Henninger of McAllen, Texas, to fill this need of the Valley citrus grower. Mr. Henninger has not only discovered and isolated a strain of Thompson grapefruit that shows a distinct pink "blush" on the outside but has combined this desirable feature with a much deeper, more attractive flesh color than that shown by the original Thompson grapefruit. Since the Thompson is a pink-fleshed sport of the Marsh, a seedless variety, it appears likely that this is a dominant gene mutation and that the new variety represents a new somatic mutation at the same locus. If this is the case, the effect is cumulative and the new sport would be expected to be homozygous for this factor.

This discovery of the "Ruby" grapefruit, as the new variety is known, came about while Mr. Henninger was walking through his grove in August, 1929, and chanced to see a windfall near one of his Thompson grapefruit trees that showed a distinct pink "blush" on the outside of the rind. Realizing the importance of such a discovery, Mr. Henninger immediately set about to find the limb from which the "blushing" fruit came. He was unsuccessful in his attempt to locate the "sporting" limb that season but renewed his efforts during the summer of 1930. After a prolonged search he found two limbs that were carrying a number of fruits showing the much sought for "blush." Several limbs originating from the main framework branch were also thought to carry the factor for superior fruit color but were removed later on after they were found to be ordinary Thompson limbs.

Mr. Henninger realized that a second budling generation would have to be produced, true to the type of the original parent limb, before he could say with assurance that he had discovered a new variety of grapefruit. He, therefore, propagated a number of budded trees from the two original limb sports and has brought these trees to fruition. The fact that these "second generation" budlings are producing fruit that shows the distinct pink blush on the outside and the deep spectrum red flesh color proves beyond doubt that a new strain has been isolated. In recognition of his discovery, the U. S. Patent Office has granted Mr. Henninger a patent on his new Ruby Grapefruit (plant Patent No. 53). Mr. Henninger deserves much credit for his work in isolating this first Valley variety and his Ruby grapefruit may prove to be a valuable contribution to sub-tropical horticulture.

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POLYDACTYLOUS GUINEA PIGS

Two Types Respectively Heterozygous and Homozygous in the Same Mutant Gene

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THE guinea pig, like all of the wild species of the Family Caviidae, has four digits on the front feet and only three on the hind feet. The thumbs, little toes, and big toes are the ones which are missing. The return of an atavistic little toe is not, however, uncommon, although presumably lost for periods to be measured in terms of geologic time. Castle in 1906[1] produced by selection a strain which breeds true to perfect development of this digit.

Crosses between this four-toed strain and normal inbred strains have given various results, in one case closely simulating simple Mendelian heredity for two generations.[2] Further analysis in this and all other cases has demonstrated that there must be multiple factors among which no one is of major importance. Occurrence depends on the crossing of a physiological threshold and not on segregation of a unit factor. It is not surprising that there is considerable influence of environmental conditions.[3] The most important of these seems to be the maturity of the mother. In a strain near the threshold, the percentage is high from immature mothers, especially from ones under six months of age.

Other Forms of Polydactyly

What seems an utterly distinct type of polydactyly is occasionally found in animals with a certain type of malformation of the legs, although much less frequent in these than is loss of digits. In this case there is symmetrical duplication of a digit rather than recurrence of an atavistic digit. In at least one case, however, the atavistic type of little toe occurred in an animal with malformed legs in an inbred family in which atavistic polydactyly had never before been recorded among several thousand young. The condition to be described next also warns against drawing an absolute line between different types of polydactyly.

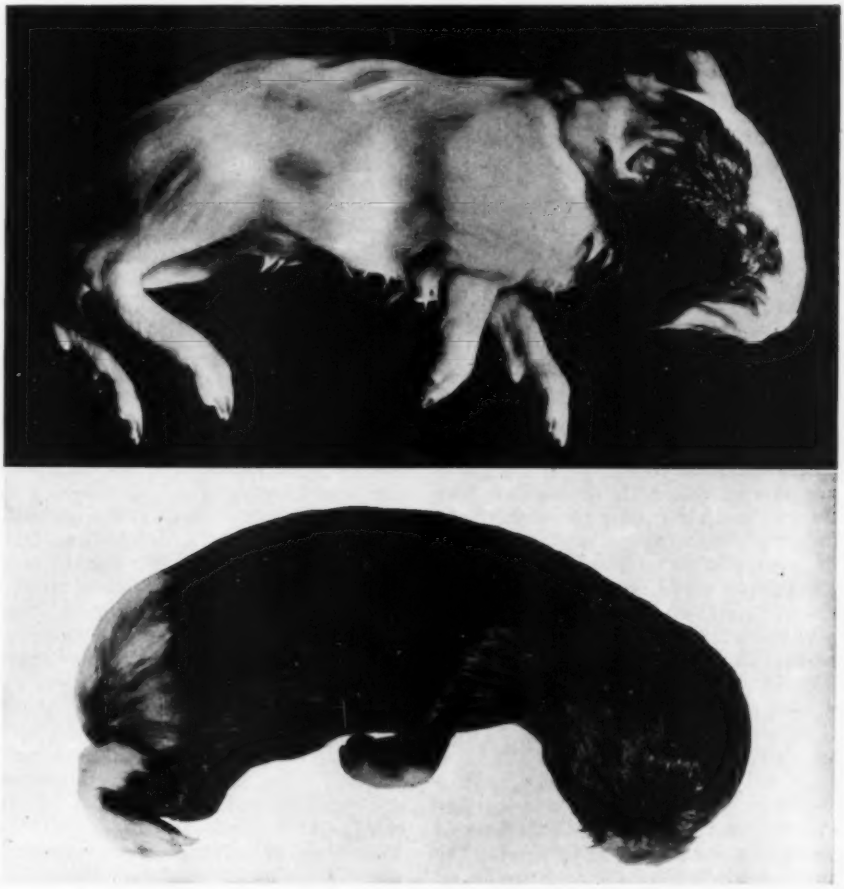
A mutant with thumbs, little toes and one big toe, all rudimentary, appeared in 1928 in an otherwise normal stock. Among his descendants there has been clear evidence of segregation of a unit Mendelian factor.[2] The heterozygotes (*Pxpx*) usually have thumbs set well back on the hands and half opposed to the fingers. The little toes are also present as a rule and are exactly like those of the common four-toed stocks. The big toes appear less frequently. The occurrence of these digits varies considerably in different outcrosses. In the original stock, some individuals have been shown to possess the gene although with no atavistic digits. In one outcross to a normal strain the thumbs are strengthened but little toes appear less frequently and big toes not at all. After crossing with the old four-toed stock, the thumbs and little toes are invariably found in heterozygotes and the big toes in more than half of them. Figure 10 shows a heterozygote with all four feet pentadactyl.

The homozygotes have turned out to be monsters which usually die at an early stage of development (10-15 mm.) but which occasionally reach birth to die at once thereafter. They have short distorted legs. The soles of the feet face the belly. Each of the feet spreads out into a paddle-

EXTRA-TOED AND MONSTROUS GUINEA PIGS PRODUCED BY SAME GENE

Figure 10

The normal (*pxpx*) on the left has four digits on the front feet and three on the hind feet. Note that the feet of the heterozygote (*Pxpx*) have five toes on both fore and hind feet. The homozygote (*PxPx*) on the right has an undifferentiated mass of digits on both fore and hind feet and is defective in other ways. Note especially the nasal cleft and the relatively undeveloped head (see Figure 11).



PROFILE VIEWS OF NORMAL AND MONSTROUS GUINEA PIGS

Figure 11

Normal (*pxpx*) guinea pig above and monstrous (*PxPx*) below. Note clubbed feet, small eye (microphthalmia), and bulging forehead of the latter. These monsters rarely survive until birth, while the heterozygotes with extra toes (Figure 10) are very vigorous, and may even be described as "super-normal" in that the number of their toes coincides with that characteristic of most rodents.

like structure with from 7 to 12 short undifferentiated digits (total numbers up to 44). The number is somewhat indefinite because of the occurrence of all grades of duplication of nails. The head also is grossly abnormal, having a bulging forehead and occasionally a protruding brain. There is always microphthalmia. In several, the nostrils have been connected with the mouth by clefts. Such a monster is shown in ventral and lateral views in Figures 10 and 11 respectively.

It is somewhat surprising that the same gene should be responsible for two such different sorts of polydacty-

ly. The thoroughly vigorous pentadactyl heterozygotes appear to be more "normal" as hystricomorph rodents than are ordinary guinea pigs or wild cavies. The homozygotes on the other hand are grossly monstrous in their type of polydactyly as in other respects. Clearly the border line between normal and monstrous types of morphological change is an arbitrary one from the genetic standpoint.

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The Story of Eggs and Poultry

THE title "Eggs" for these two books* is somewhat of a misnomer since, in addition to eggs, chickens, turkeys, ducks, and geese are considered in both books. The books include a variety of subjects not only for those engaged in the keeping of poultry but also for the much larger group — the people who eat the chickens and the eggs. Subjects are also included of interest to the processor, dealer, teacher, and scientist.

Book I contains a brief history of poultry and eggs, approximately one-third of it being devoted to poultry keeping. The chapter on "The mystery of the egg and chick," by Edward N. Wentworth, Jr., is written clearly, and includes a discussion of the formation of egg and its parts, the process of fertilization and the development of the chick.

In the chapter on "How cold storage came to the rescue," is given a much needed and often neglected story of the cold storage of eggs and poultry, which is especially valuable. It includes a description of how eggs are tested, how cold storage keeps good eggs good, and how eggs are transported. It also includes a brief story of the processing of eggs and the use of processed eggs.

The final chapter, written for the consumer, flock owner, and market man, discusses some price curves and consumption facts. It also points out the road to progress.

Book II should be of great interest to consumers of eggs and poultry, and this includes people in all walks of life. Mrs. Snyder writes clearly and interestingly of the place of eggs in the diet and in cookery. Many valuable hints are given on the buying of eggs with a discussion of consumer preferences.

The hows and whys in cooking poultry from broiler to fricassee are well related. The housewife will appreciate the illustrations of how to cut a chicken to make from 4 to 7 portions. The men folk will more than welcome the discussion of and directions for carving a bird.

Of especial interest to the housewife are 800 recipes given in a brief, clear, and simple manner. These recipes are of considerable value in the preparation and use of eggs and poultry.

These two books are a source of considerable information and should be a welcome addition to any general agricultural library.

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Bureau of Animal Industry

*Pennington, Mary Engle, Platt, Frank L., Mandeville, Paul, and staff. *Eggs.* Book II by Clara Gerhard Snyder. Progress Publications, Chicago, 1933.

A STATISTICAL STUDY OF A TYPICAL SOUTHERN GENEALOGY

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MANY genealogies have been compiled and published, mostly by persons with scholarly tastes and plenty of leisure and enthusiasm, and little hope of pecuniary reward, but generally little use is made of them afterward except by persons seeking information about their more or less distinguished ancestors. However, any one who is willing to spend a little time analyzing a genealogy can dig out from any reasonably complete one a multitude of significant facts about age at marriage, length of generations, size of families, etc., which may be typical of a large population.

Most American genealogies, apparently, begin with New England, because that part of the country has been longest settled by scholarly people. There are, however, quite a number of southern ones, dealing with families that migrated from England to Virginia or thereabouts in the 17th or 18th century and gradually drifted farther southward or westward. One such, dealing with the Key family, has lately come into the hands of the writer. It is a book of 495 pages, containing about 12,000 names, compiled by Mrs. Julian C. Lane of Statesboro, Georgia, and published by her in 1931. It has the distinct advantage over most others of bringing the records well down into the present century, and including several people born since 1900 who already have children.

As is inevitable in genealogies, many of the records are incomplete, especially as to dates. But I have picked out from it reasonably complete records of about 1,100 families with about 5,300 children, which is a fairly adequate sample for statistical purposes. Where dates of birth or marriage are lacking they can often be approximated closely enough by means of other dates given. Unfortunately the book is marred by many typographical errors, involving dates, and even the number of children in a family is sometimes uncertain, on account of the punctuation, or the practice of running three or four generations into one paragraph, with the same kind of type and no serial numbers. But in many such cases the error is self-evident and can be corrected by the reader; and errors that escape detection tend to balance each other when many records are combined. And records that are too indefinite are not used.

The book is divided into several sections, dealing with different Key ancestors who migrated from England at different times (and who may or may not have been closely related), and with several other family groups that have married into the Keys. Some of the Keys themselves after coming to America spelled the the name in different ways, sometimes purposely to avoid confusion, and sometimes carelessly in the days when spelling was not well standardized and many people were illiterate. The principal variants listed are Kay, Kea, Kee, Keyes and Keys.

In the following analysis all the different branches have been combined for statistical purposes except the first two, which have been kept separate for geographical reasons. The first begins with Philip Key, who was born in England in 1696, and migrated to Maryland in 1720. He was the great-grandfather of Francis Scott Key (to whom many pages are devoted). The members of

this branch whose residences are recorded lived mostly in Maryland, and very few came farther south.

The second branch begins with John Key, a member of William Penn's colony, who came with his wife from England to Pennsylvania in 1682. His descendants about 100 years later changed the name to Kay, and most of them seem to have lived and died in Pennsylvania, particularly in Bedford County. Several moved to Ohio and farther west, but none is recorded as having lived south of Kentucky. These two northern branches are not used in the statistics, except in the study of size of families, and there they are kept separate from the others for comparison.

As in most other genealogies, definite information about birthplaces and residences is given in less than half the cases; but it is evident enough that the remaining branches were for the most part typical southerners. A few indeed settled first in Massachusetts, but their recorded descendants moved southward. As far as the records show, up to 1790 more of them were born in Virginia than any other state. From about 1790 to 1890 Georgia was far in the lead, and it was then overtaken by Alabama. One line settled in the Bahamas, and some of those moved later to Key West, Florida.

Of those born in the middle of the 18th century, nearly as many finally lived in South Carolina and Virginia as in Georgia, but in the next hundred years Georgia was in the lead as a state of residence, and it was then supplanted by Alabama, with Texas not far behind, illustrating the westward migration of many southern families.

As well as we can judge from incomplete data, nearly half the southern Keys and their descendants were born in Georgia, Alabama, or Texas, and a trifle over half had their last residence in one of those three states.

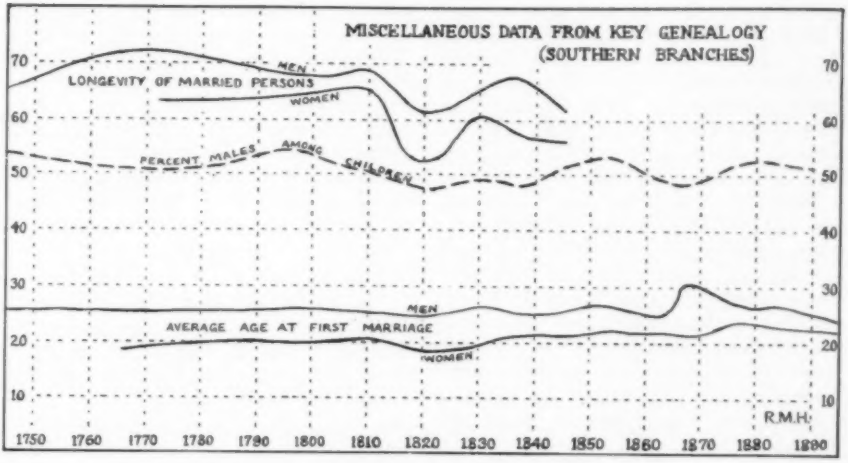
Occupations

A few words may be said about occupations. Those are specified in only a small number of cases, perhaps not one in ten, but it is a reasonable assumption that most of the men were farmers, for most of the people in the South have lived on farms until quite recently. The occupations indicated range all the way from statesmen, public officials, lawyers, doctors, ministers, to merchants and at least one barber and one coalminer. The Keys and their near relatives therefore presumably represent a typical sample of the white population of the South, exclusive of the small illiterate and criminal elements (which, of course, would hardly appear in genealogies).

Sex Ratios

Turning now to the statistics of families, the sex ratio may be considered first, for that is fixed at birth. The middle curve in Figure 12 shows the per cent of males among the children, arranged according to years of birth of the parents (assembled in five-year or longer groups in order to have enough data for accurate averages). In the genealogy the sex is sometimes uncertain, as when the number of children is given without their names, or when the given name is ambiguous (e. g., Marion, Willie), but such uncertainties should balance each other pretty well in the long run. In any large number of births there are nearly always a few more boys than girls, and the per cent of males in all the southern Key families combined is 51.0, corresponding to a sex ratio of 1.04, which is quite close to the present national white average. The fluctuations from one decade to another shown by the curve would be more significant if larger numbers were involved, but the distinct rise after 1837, and the depression in the 60's, probably do mean something.

It was noticed long ago that the proportion of boys born tends to in-



VITAL STATISTICS OF THE SOUTHERN KEYS

Figure 12

Longevity of married couples, sex ratios of children and average age at first marriage, for the southern Keys and their relatives. The dates at the bottom are birth dates and the numbers at the sides are percentages for the middle curve and ages for the others. Note that for the middle curve the years are not those when the children were born, but when their parents were born. For example, the average married man of this stock born around 1820 married at the age of 25, had 48% of his children sons, and died at 61. The curves for women do not go as far back as those for men, because there were too few women in the early generations for accurate averages.

crease during and soon after a war; and the statistics of sex ratios of children under ten years old, in Georgia and other southern states, show this unmistakably in the sixties and seventies. The parents of such children would be likely to have been born around 1840, when the curve just mentioned was trending upward.

Age at Marriage

It seems to be a rather common belief at present that people marry later now than they did a generation or more ago, perhaps on account of spending more time getting an education. That may be true of college graduates, who indeed form a larger proportion of the population now than formerly, but they are still relatively few, and they must be pretty well counterbalanced by an increasing number of persons who rush into matrimony without "looking before they leap," for available statistics for the United States do not show much change other than temporary fluctuations, and a slight downward trend in the last decade or two. The two lower curves in Figure 12 show the average age at first marriage of men and women (both Key descendants and their spouses) born in the years indicated at the bottom. The age of marriage is given for about two-thirds of the married descendants studied, and for many of their spouses besides, so that these data ought to be representative enough. In some cases where the date of marriage is not given it can be approximated closely enough by assuming that it was a year before the birth of the first child, especially where the couple is so young that it could not have been much earlier than that. As before, these data are assembled by periods of five years or longer, in order to eliminate random fluctuations.

For men the average age at first marriage remained between 25 and 26 most of the time up to 1860 (meaning those born then) and then went up pretty sharply for those born immediately after the Civil War, and has trended downward since. The average for women born before 1830 was close to 20 (with a few marrying as early as 13 or 14 if the dates are correct), and after that there was a distinct upward trend for fifty years or so. In the 18th century the men were about six years older than their wives (assuming that all ages were given correctly), while in 1895 (meaning those marrying around 1920) there was only two years' difference, apparently.

Of course some men born in the 80's and 90's may not be married yet, and if they do so later that will raise the curve for men a little. But United States census figures show a tendency for men to marry a little earlier in recent years, which may be due partly to an increasing proportion of women in the population, and partly to the income tax, which penalizes bachelors. This tendency, while doubtless approved by some, is unfortunate in a way, for early marriages seem more likely to end in divorce than late ones.

Second Marriages

About 22 of the men and 11 of the women are recorded as having married more than once, with both dates given, but the total number of second marriages must be about double these figures, or say eight per cent of the men and five per cent of the women. The men who married twice, according to the available figures, did so the first time at the age of 23.3 and second at 39.3, and the women at 21.8 and 33.2. If similar data were available for the whole white population of the South (which is not the case), they probably would not differ much from these. There are not enough third marriages to be worth averaging, though one woman is said to have married six times. Only one divorce seems to be mentioned (that occurring in 1925), but of course there may have been others, that were not "shouted from the housetops." However, as is well known, divorce has been rare among respectable people until very recent times.

Longevity

The longevity of married persons is shown by the two upper curves in Figure 12. These curves end at 1845, for an increasing proportion of those born after that are still living, and when they finally die they will make the averages higher than they would be if based only on those who have already died. The men of this group seem to have always lived longer on the average than the women, which is not true in modern times, especially in cities. Perhaps the hardships of a farm woman's life may be the best explanation of this difference. Another factor is that some of the married women died at an age when most of the men were not yet married.

The surprising thing about these longevity curves is their downward trend in the 19th century, in spite of the great progress of medical science in combating disease. Persons born in the 18th century lived and died at a time when medicine was in its infancy, and nothing was known of anaesthetics, germs, calories or vitamins, and yet most of the married men of that period rounded out the proverbial three-score and ten, and the women about five years less, while those born around 1845, many or most of whom lived into the 20th century, had about eight years' less expectation of life.

This seeming paradox may be explained as follows. Medical science has had its greatest success in combating germ diseases which formerly carried off many children and young adults, but it has made little headway

yet with chronic diseases to which middle-aged and older people succumb. And indeed many people with weak constitutions, who at an earlier period might have died from some of the common ailments of childhood, are now saved to grow up and perhaps marry and have a few children, and then become an easy prey to heart disease, cancer, or something of the sort. So perhaps in this way the human race is gradually becoming weaker instead of stronger.

Persons who grow up and marry have of course escaped or survived the ills of childhood, and then they have to have reasonably good health in order to marry. Men who die say around 25 or 30, unless from accidents or epidemics, are not very likely to have ventured marriage before that, on account of poor health. Another point to be considered is that doubtless a larger proportion of the 18th century people listed than of the 19th were healthy enough to have children and grandchildren, for if there were any childless couples in the 18th century they would be less likely than those with large families to be included in a 20th century genealogy. A few years ago Miss Alice Gould, by a study of unpublished family records and several northern genealogies,* showed that the average longevity of grandparents—including those who did not live to see their grandchildren—was 70.7 years (men 70.98, women 70.33), as compared with 61.85 (men 60.68, women 62.96) for people who had children but never any grandchildren.

Size of Families

The most significant inquiry is that relating to the size of families, or total number of children born to each couple. The calculations are based on the original immigrants and all their married descendants whose dates of birth are given, or can be approximated closely enough to put them in the proper decade, and whose children are enumerated, or who are listed as childless. No married persons born since 1895 are included, for their families may not be complete.† The children of male and female descendants have been kept separate, except in some of the curves which combine them, as indicated.

An element of uncertainty is caused by the fact that, as is probably the case with all genealogies, some of the descendants were not followed up far enough to see whether they ever married or not, or if married, whether they had any children or not; and such may have had more or fewer children than their brothers, sisters or cousins who are more fully reported. But it is assumed that any such omissions would balance each other pretty well. Where a marriage is indicated and nothing is said about children, however, it is not assumed that there were none, unless there is strong presumptive evidence to that effect; and such incompletely reported couples are usually disregarded.

Another difficulty is that even if the genealogical work was absolutely complete and accurate, the method here used, of averaging up the children of all married couples, does not quite tell the whole story. For it would be theoretically possible for a certain family, or many families at about the same period, to have say six children, and only one of those married, and that one again have six

*Longevity of grandparents.—*Eugenical News* (Cold Spring Harbor, N. Y.) 12:166-171, 175-178. Dec., 1927.

†As in every genealogy, it is of course impossible to have all the thousands of records equally up to date; and although the book was published in 1931, and some births and deaths as late as 1929 are included, the records of some families must be a few years older than that. For example, on page 130 a girl born in October, 1909, is said to be "now 17 years old," which seems to indicate that the information was communicated in 1926 or 1927.

children. That would indicate a dwindling stock, the same as if three married but had only two children each, but the resulting graph would be quite different. About the best we can do under the circumstances, until more refined methods are devised, is to assume that the proportion growing up and marrying is about the same in each generation.

Still another thing to be considered is that some families are limited, not voluntarily or by any lack of vigor, but by the early death of one parent from accident or an epidemic. However, there is certainly no reason to suppose that such cases are any more frequent in later than in earlier periods. And in spite of all these possible sources of error, the secular trend toward smaller families is unmistakable, and perfectly consistent with the results obtained from census data and various other sources.

Figure 13 shows the average number of children per family for parents born in the years indicated by the scale at the bottom. From 1836 on the families are assembled in five-year groups, but for earlier periods longer intervals are used, to compensate for the smaller numbers. The upper continuous line is for both men and women, in the southern branches, and the dotted lines are for men and women separately. That for men goes back considerably farther than that for women, for the earliest records are more complete for men than for women, and the proportion of men may have been larger among the early settlers than it is today anyway. The lower continuous curve is for the Key and and Kay lines of Maryland and Pennsylvania, combined because the number in each is too small to warrant separating them.

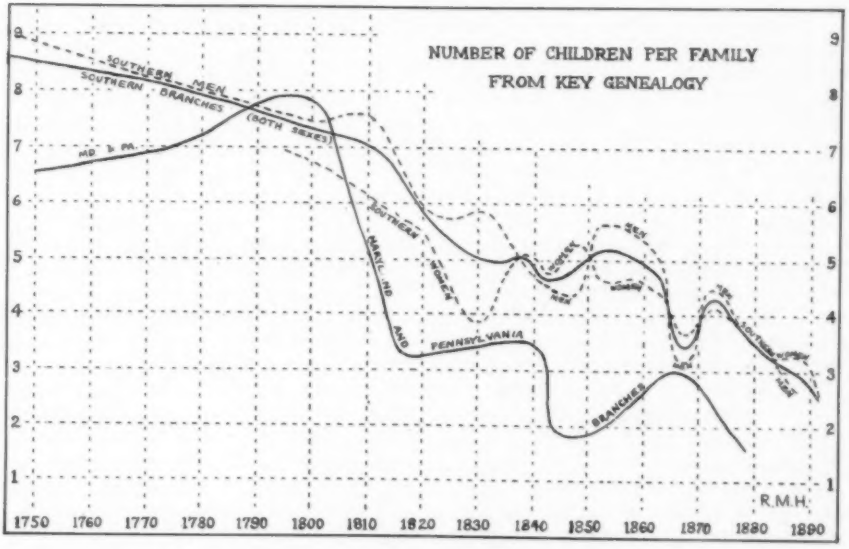
If no person married more than once, the curves for children of the two sexes should practically coincide; but the men usually have a few more children than the women because more of them marry twice, as already indicated.

In the 18th century families of seven or eight children seem to have been the rule in all branches of the Key family; and this agrees very well with the indications of other genealogies, and with an observation attributed to Benjamin Franklin. Just what may have been the condition in previous centuries cannot be stated with certainty, but it does not seem probable that the American Indians before the arrival of Columbus, or even the cave men of the Stone Age, could have averaged much more than eight children apiece, for it would have been too great a burden to feed them.

Since the 18th century the trend has been decidedly downward, until by the end of the 19th century the southern Key descendants (referring of course to those born then, and marrying say 1920-1925) were having less than three children apiece, which is supposed to be the minimum necessary for the perpetuation of the human race (for some die in childhood and some who grow up do not marry or do not have children). Of course the curve may be a little too low at the right, for some people born between 1885 and 1895, or even earlier, may have one or two more children yet; but families that looked as if they might be incomplete were left out of consideration.

Descendants of Francis Scott Key

The Maryland and Pennsylvania lines have dwindled faster, and seem to have almost died out, unless they have some descendants that the compiler overlooked. A striking case is that of Francis Scott Key himself. He had 11 children and 45 grandchildren, which should have been enough to assure at least 100 in the next generation. But the book records only 28 great-grandchildren (born between 1856 and 1896), and only 15 (mostly females) in the fourth generation (1892 to 1917).



THE FALLING KEY BIRTH RATE

Figure 13

Average number of children in presumably completed Key families at different periods, separating the Maryland and Pennsylvania branches from the more southern ones. The years at the bottom indicate dates of birth of married persons, as in Figure 12. The upper continuous line is for the four southern branches combined, and the dotted lines adjacent are for men and women separately. The lower continuous line is for the Francis Scott Key tribe of Maryland and the Kays of Pennsylvania combined. At the present time both branches are having families smaller than are required to maintain a stationary population.

Most of the great-grandchildren are still living, and it should be easy enough to get information about them and their descendants, so that it does not seem likely that many were overlooked.

In the Kay line of Pennsylvania, the last married man recorded was born in 1860,* and the last married woman in 1844, and neither of those appears to have had any children.

The irregularity of the main curve may be due in large measure to the use of rather small numbers in computing averages, as is indeed indicated by the still greater irregularity of the curves for men and women separately. But there are two depressions which have not been found in the statistics from northern genealogies, and may reasonably be ascribed to the Civil War, which involved a much larger proportion of the population of the South than of the North. Persons born around 1840—and ultimately married—had fewer children than those a little older or younger, probably because the war interfered by taking many young men away from home, and of course killing many of them. Those born between 1860 and 1865 had decidedly fewer than those five years older, and there was a still further drop in the next five years, followed by a temporary recovery.

*The writer was well acquainted with this man, who was a professor at the University of Alabama from 1903 to 1912 (listed in *Who's Who in America*), and died about the time this genealogy was published.

This sag in the 60's, which affected both men and women, may indicate that children born during the trying days of war and reconstruction were weaker than usual, and less fitted to raise large families. This however should be tested by a study of a few other southern genealogies before being asserted as a general principle.* It is a curious and perhaps significant fact that the people born during the 60's had more daughters than sons, as is indicated by the middle curve of Figure 12, and that the men of that period married later than usual, as shown by one of the lower curves.

Conclusion

As stated above, the Key tribe (southern branches) is believed to be quite representative of the white population of the South, outside of the small illiterate and criminal elements which are found everywhere. Census figures give us ample evidence of shrinking families in this and other civilized countries, especially since 1850, when the first reasonably complete count of (white) families was made in the United States. But it is probable that the decline in the South as a whole has not been quite as sharp as these curves indicate, for two or three reasons.

First, the families represented in this or any other genealogy may have been larger than the average in the 18th century, for even then there must have been some families with few or no children, that have since died out and are not represented in any modern genealogy. Second, genealogies are generally written by persons with few or no children (for others would hardly have time), who have more ancestors to look back to than descendants to look forward to, and such persons may have many brothers, sisters and cousins similarly situated. So the genealogy families at the time such works are written are likely to be smaller than those of their neighbors. The possibility of some of the latest families being incomplete has been mentioned above, and guarded against to some extent.†

The shrinkage of families (or declining birth-rate, which amounts to the same thing) is practically a world-wide phenomenon, and it has been discussed by many writers, who are far from being in agreement as to its fundamental causes. No attempt will be made to solve the problem here (except as suggested above under the head of longevity), for that would extend this article beyond reasonable limits. Neither will any predictions be made now about future developments, which certainly do not look very encouraging. But we should know a good deal more about it a decade or so hence.

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*An interesting corroboration of this was found by the writer in the fall of 1933, in a study of about 100 farm families in northeastern Alabama. The farmers born around 1896 (whose parents were born mostly in the late 60's) had fewer brothers and sisters than those born a little earlier and later, perhaps for the reason here suggested. There is a possibility, however, that the nation-wide hard times between 1893 and 1898 may have had something to do with it, too.

†In this connection see Ellsworth Huntington, A Neglected Tendency in Eugenics (*Social Forces*, 12:1-8, Oct., 1933); especially graph on page 2.

WOOLLY HAIR IN SWINE

A. O. Rhoad

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In October, 1929, while examining the herd of swine at this college, the writer noticed a native pig with a peculiar hair character. On inquiry this character was found to be one quite often encountered in swine of the region and known locally under several names, "cabello do negro" or negro hair, "cabello torcido" or curly hair, and "cabello enrolado," crinkly or woolly hair. Any one of these local designations of the character describes it equally well and these names for this type of hair will be used interchangeably in this article.

Description of the Character

The woolly hair condition extends over the whole body, there being no regional differences in hair type. Specimen hairs taken from any part of the body show an anatomical similarity with hair taken from any other part especially with reference to the flattened shaft, an anatomical peculiarity of woolly hair. In man the hair of the ulotrichous or woolly-haired races (Bushmen, negroes, etc.) is characterized, in cross section, by the flattened oval or kidney-shaped shaft and frequently by absence of the medulla. Mohr[2] describes the same structure in woolly-haired Nordics. In normal straight hair the shaft, in cross section, is roundish or oval.

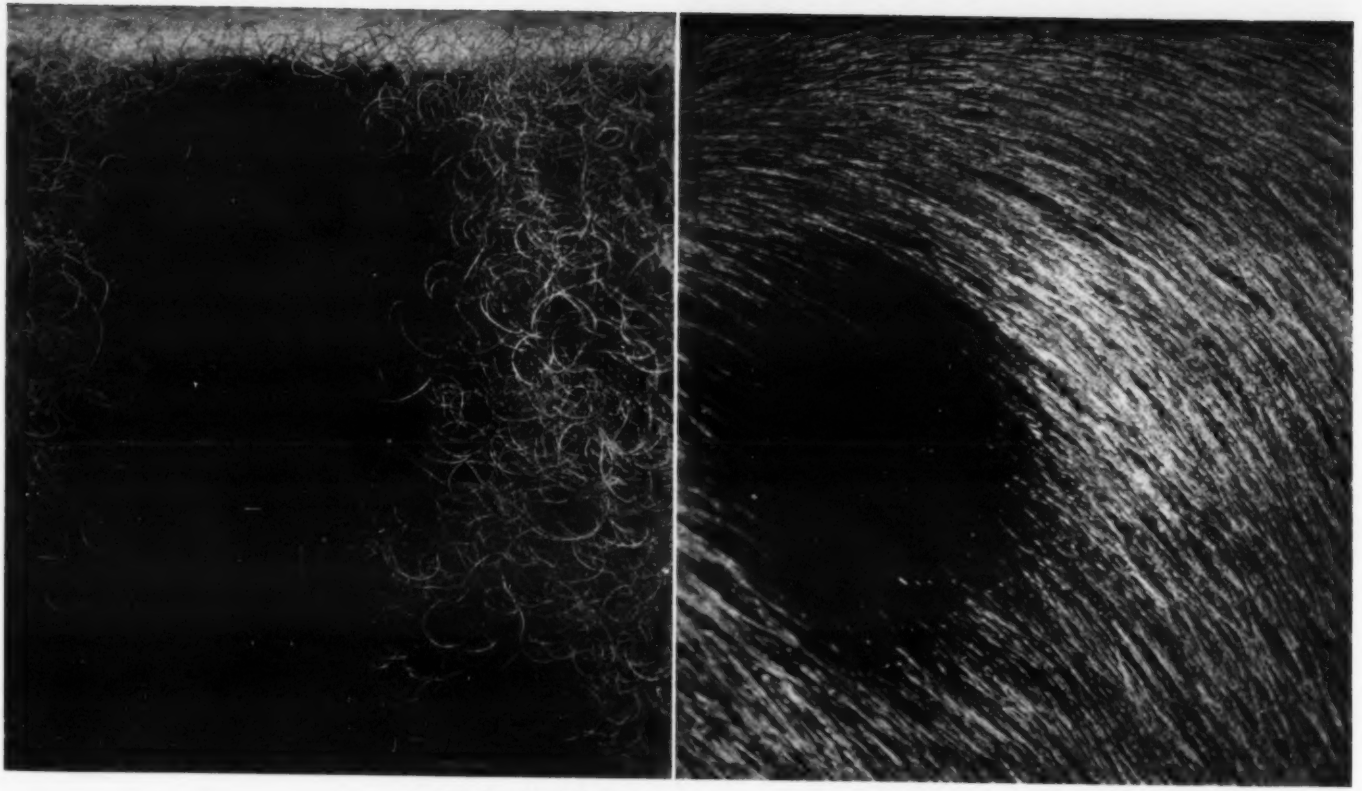
Although the woolly condition extends over the whole body it is not always equally pronounced for in those parts that constantly come in contact with other objects, such as the legs, face and sides, the ends of the hairs are rubbed off and their curling tendency partially disappears. In swine, as in other animals, the crinkly hairs are crisp and break easily.

In new born pigs the crinkly condition is not so pronounced as in older pigs, however, the woolly-haired individuals can be readily distinguished from their normal straight-haired brothers and sisters. With age the woolly condition becomes more pronounced until at eight or ten months the hair is distinctly curly.

From observations made on farms and from data derived from the college herd it is apparent that the factor for curly hair is independent of the factors for color and pattern. The woolly condition is found in combination with all common coat colors, black, however, predominating.

The somatic manifestation of the character is remarkably constant. Among the many affected animals that the writer has examined he has not encountered any adult individual whose coat would be considered a blend between the woolly and the normal condition, disregarding slight variations in tightness of curl. Some individuals have a more open curl than is illustrated in Figure 14. The persistence of the tightness of curl is clearly brought out in the various crosses. When pigs heterozygous for the woolly state were crossed with pigs of another breed homozygous for straight hair the coat of the woolly-haired progeny was as tightly curled as that of the heterozygous parent. In this respect woolly hair in this study resembles the woolly hair type described by Mohr in Nordics. It is not like the woolly hair of the negro races that blends when crossed with straight-haired races, producing a wavy condition in the hybrid. In other words the woolly condition in swine behaves in outcrosses as a clear cut mendelian monofactorial dominant.

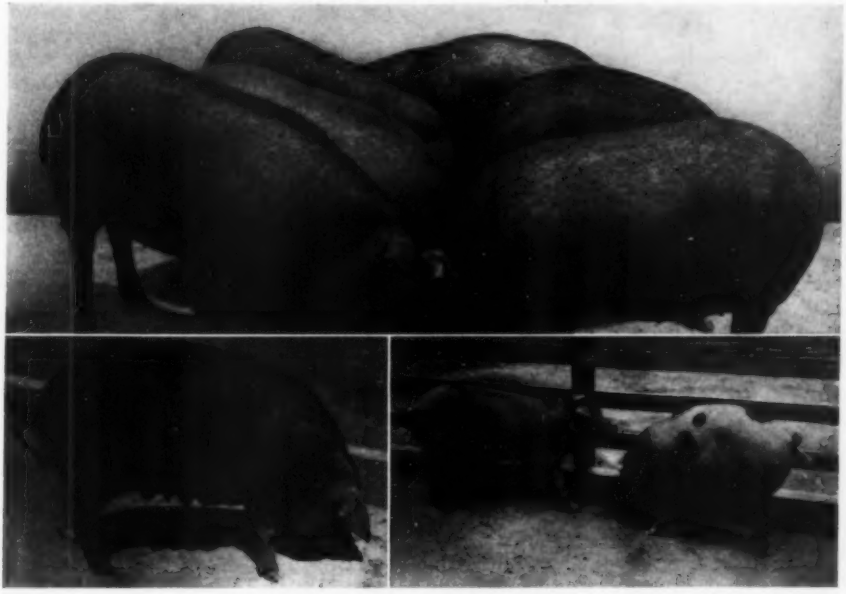
Some of the individuals studied showed a greater or lesser abundance



WOOLLY AND NORMAL HAIR OF LITTER MATES

Figure 14

Sections of skin of numbers 7 and 8 in generation II of the pedigree (Figure 16). This woolly type of hair is inherited as a mendelian dominant which appears to have occurred spontaneously in Brazil. It does not seem to have any direct relationship to the woolly Bakonyer pigs of Hungary. This mutation is an interesting parallel to the mutation in human hair form discussed elsewhere in this number (see page 337).



WOOLLY PIGS

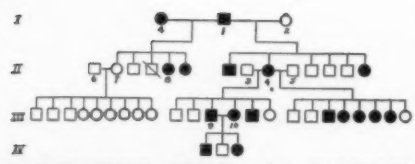
Figure 13

Above is shown a group of woolly pigs to be compared with a pure-bred Poland China (right center). Some of the woolly pigs also carry a gene for partial hairlessness which is inherited independently of the genes for woolly hair. The sow in the right foreground is number 10 on the chart (Figure 16) and was used for breeding purposes in this study. Below at the left is shown the sow (number 4 in the pedigree chart, Figure 16) used in this study for three critical matings with two normal boars and in a backcross to her sire. At the right are shown two litter mates, details of whose skin are shown in Figure 14. The left hand individual is woolly and the right straight-haired. Both have an equal quantity of hair but the woolly hair gives an effect of being more scanty. Both pigs are dark skinned.

of hair as compared with the native breed, Canastrao, in which the woolly condition appears. This breed also carries the factor for congenital hairlessness, a condition found by Roberts and Carroll[4] to be partially dominant to normal abundance. See Figure 15.

The ancestors of the Canastrao breed were brought to Brazil by the early Portuguese colonizers. It is of interest in this connection that, according to Ritzoffy,[3] the Turopoljer breed in which are found one smooth-haired and one curly type, is derived from the *Sus mediterraneus* as first shown by Ulmansky. It is not, however, possible to judge from the pictures presented, whether the curly character of the Turopoljer breed is identical with the one here dealt with, nor has it been possible because the necessary material for comparison is lacking, to decide, whether the curly hair character encountered in the Canastrao is identical with that occurring in other curly breeds of pigs, as for instance the Hungarian Bakonyer breed.

According to Landauer's[1] statement in his extensive review on the inheritance of hair and skin characters, nothing is known as to the inheritance of the curly hair types in pigs.



A PEDIGREE CHART OF WOOLLY HAIR IN SWINE

Figure 16

The sow designated as "4" was mated back to her sire to produce a progeny of three normal and two curly haired. In matings with two normal sows she produced six straight-haired and seven woolly offspring. The excess of woolly individuals is not greater than might be reasonably ascribed to chance. The character is evidently a simple mendelian dominant in inheritance.

Mode of Inheritance

From the pedigree chart it is evident that the woolly hair character in swine is inherited as a clear cut autosomal dominant, allelomorphic to normal straight hair. The chart, Figure 16, represents four generations of pigs in which several outcrossings, one backcross and one brother-and-sister mating were carried out for the purpose of studying the mode of inheritance of the woolly hair condition. An examination of the pedigree shows that when a woolly-haired pig was crossed with either a straight-haired or woolly-haired pig the woolly and the normal state segregated in the progeny in accordance with expectation. All of the curly-haired animals used proved to be heterozygous for the character.

The character was introduced into the college herd by a Canastrao boar, No. I on the chart. He was a large black pig with white markings on face and legs and following Roberts and Carroll's[4] classification was heterozygous for "hairlessness." He was used in the herd part of the seasons of 1929 and 1930 leaving a number of normal and woolly-haired progeny exhibiting varying degrees of hairlessness. In the early part of 1929 this boar was mated to a solid black Canastrao sow, No. 2 on chart. This sow had a rather abundant coat of normal straight hair. From this mating a litter of six was produced, four males one of which had woolly hair and two females both of which had crinkly hair. In this litter the sow Parhybana, No. 4, is of special interest in this study. She was a large, solid black pig with a good covering of crinkly hair. See Figure 15. Her first litter was obtained in a mating with her own sire, No. 1, and consisted of two males, one normal (the hair type of the other male unknown), and three females, two of which were woolly. See chart, line 2 and Figure 15. The normal smooth-haired gilt of this litter, No. 7, was mated to a pure-bred Poland China boar, No. 6, producing a litter of nine normal straight-haired, spotted pigs.

In the latter part of 1931 Parahybana was mated to a pure-bred Duroc Jersey boar, No. 3, and farrowed a litter of six, four male pigs, two of which had typical woolly hair, and two females, one of which, No. 10, was curly-haired. Parahybana's third litter was obtained in a mating with a pure-bred Poland China boar, No. 5 on chart. Of the three males in this litter one was affected and of the five females four had typical woolly hair.

After weaning the above litter, Parahybana was eliminated from the herd and her daughter, No. 10, was used in her place. See also Figure 15. This sow had a dense coat of woolly red hair. In November of 1932 she was bred to her litter mate, No. 9, a black pig with only an average abundance of woolly hair. The result of this mating was a small litter of three pigs, one affected female and two

TABLE I.—Results of matings of woolly × woolly, woolly × straight haired, and straight-haired × straight-haired in Swine.

Matings		Progeny			
Type	Frequency	Woolly		Straight	
		♂	♀	♂	♀
Ww × Ww	2	1	3	2	1
Ww × ww	3	4	7	8	2
ww × ww	1			6	3

males, one of which had normal smooth hair.

Using the symbol W = woolly condition and w = normal straight-haired condition the various matings and their resulting progeny are given in Table I.

Although this study involves only six matings and 37 progeny the results accord so closely with the expectation that it leaves little doubt as to the mode of inheritance, the woolly hair condition in swine being transmitted from parent to progeny as a simple autosomal mendelian dominant.

Conclusion

The results of the six matings as described above and as shown in the pedigree chart represent sufficient evidence to indicate that the woolly hair condition in swine is due to a single mendelian factor completely dominant over normal straight hair, the recessive condition. The factor segregates as an independent gene not being associated with coat color, coat pattern or sex. The data of this study are not sufficient to determine the gene's relationship, if any, to the gene for congenital hairlessness. Neither has the effect of the dominant woolly gene in homozygous condition been determined so far.

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4. Roberts, E. and Carroll, W. E. The Inheritance of "Hairlessness" in Swine. *Journal of Heredity*, Vol. 22: 125-132.

◆

The "Literature Cited" of Plant Genetics

THE growth of an idea resembles in some respects the growth of an organism. Since ideas may be held to be biological phenomena this simile may not be too great a strain on reality. Thus in the case of plant genetics we may liken the fertilization of the egg to the discovery by the ancient Babylonians that plants are sexual organisms. This is followed by a long period during which the "embryo" remained in a dormant state with slow changes which eventually led to germination in the relatively short period between Cotton Mather's notes on fertilization in maize (1717) and Mendel's announcement of discrete heredity in 1866.* With the publication of Mendel's papers the "growing point" of plant genetics may be said to have reached above the ground and pushed forth its cotyledons. Some plants, notably those in an arid environment, have a very long "latent period" following emergence from the ground. From 1866 to 1900 was such an arid period in experimental attacks on problems of heredity and the new "plant" grew slowly. With the triple rediscovery of Mendel's Law in 1900 the juvenile stage was past and a more rapid growth commenced, which in the next 34 years has culminated in the robust and the astonishingly varied organism which is plant genetics today.

When we consider the varied techniques that are in use today in addition to the breeding plot and the progeny test of 30 years ago, we may be justified in considering that our "genetics plant" has indulged in a number of bud mutations. Thus we have what might be labelled the Evening-Primrose-Jimson-Weed mutation, which has enormously increased the growth rate of our knowledge of the effect of varying doses of "gene-pills"

*Zirkle, Conway. Plant Hybridization Before Koelreuter *Jour. Hered.*, 25: 3-18. 1934.

and their distribution in the "chromosome bottles." One branch of this "mutant" has given rise to laboratory species, as has recently been reported in the JOURNAL. We have the "X-ray-radium mutation," which has spread over all the world, and has set hundreds of investigators to shooting plant and animal genes and chromosomes with X-rays and radioactive particles. We have a mutation of cooperative research in the organized exchange of information among maize geneticists, which, while it may somewhat cramp the style of the rabid individualist, nevertheless greatly facilitates the accumulation of knowledge. We have had several mutations in cytological approach which have given us an enormous mass of new information about how genes and chromosomes behave in cell division. The implications of some of these discoveries are still a matter of no little controversy. In fact our "plant genetics plant" has grown so fast and had such a variety of bud mutations that it might be difficult to recognize it as a single organism had it not grown up almost before our eyes.

In the nature of a herbarium exhibit of progress in this field is a very important bibliography just issued by the Library of the U. S. Department of Agriculture.* The 10,156 entries listed therein are based mainly on the material in the catalogue in the library of the Bureau of Plant Industry and to some extent from other sources. No claim is made that the subject is completely covered, although an attempt has been made to limit the entries to really significant contributions. Bibliographies are rather dull reading but a glance through this one, if imaginatively undertaken, does have much of interest. The earliest reference noted is to Nati's description in 1674 of the Florentine bizzaria. This same graft hybrid is still in existence and until recently has been an enigma to plant physiologists.† Koelreuter's fifty-page "letter" on sex in plants is not available in the original in this library, but in a reprint issued at Leipzig in 1893. Eight other papers by Koelreuter concerning hybrids in phlox, foxglove, lobilia, datura, etc., are available in the original. Mendel's original paper is entry No. 6,106 in the list, and the papers announcing the triple rediscovery of his work by De Vries, Correns and Tschermack are Nos. 9384, 1802 and 9088. The references are, of course, both full and complete during the later years, when publication and distribution has been most active. The reference literature to these recent developments is almost overwhelming in amount. Thus, in the subject index under maize are over a page and a half of small type references to citations in the bibliography. Many of these entries also bear a star, which indicates a list of additional literature. The searcher for printed information has a long and tortuous path laid out before him. Thus we may say that this bibliography is essentially a skeleton résumé of the progress of plant genetics from its inception as a science in 1866. It extends only through 1930, so that it embraces the period from Mendel's work to the death of Karl Correns, the second of Mendel's rediscoveries.

References to A. G. A. Publications

This bibliography also gives an opportunity to evaluate, at least numerically, the place in the literature of plant genetics which is occupied by the publications of the American Genetic Association. There are 10,156 entries in the entire bibliography. By

*"A Bibliography of Plant Genetics." Compiled by Marjorie F. Warner, Martha A. Sherman, and Esther M. Colvin, of the Library of the U. S. Department of Agriculture. The United States Department of Agriculture Miscellaneous Publication No. 164. Washington, D. C., April, 1934., pp. 552. (For sale by the Superintendent of Documents, Washington, D. C. Price 50 cents.)

†SWINGLE, C. F. Graft Hybrids in Plants, *Jour. Hered.*, 18: 73-94, 1927.

actual count 764 of these are to publications of our Association.* Thus 7.5 per cent of all citations are to these publications. The bibliography covers the publications of the entire world, and it seemed of interest to find what proportion of publications in this field originated in the United States. It seems likely that the bibliography is probably more complete for American references than for those of the rest of the world—but most of the important foreign publications are represented. Some difficulty was encountered in classifying a few of the publications, but the number was so small that the error would be insignificant. Of the 10,156 references 4,268 were published in the U. S. and 5,892 in other countries. Thus 42 per cent of all references originated in the United States. Of these, 17.25 per cent appeared in the publications of this Association.

Only a rough estimate was made of the number of publications listed in this bibliography. There were 130 publications (periodicals, proceedings, books, etc) listed in 1,500 citations, taken as three samples in different parts of the book. Possibly twice as many would be found in the entire bibliography. When it is considered that this list includes not only periodical publications but the bulletins of the U. S. Department of Agriculture and of the experiment stations, in all parts of the world, books, articles in such magazines as *Popular Science Monthly*, and other miscellaneous publications, we may feel that our Association has taken no mean part in diffusion of knowledge regarding plant heredity. It is impossible of course, to arrive at a figure for the proportion of illustrative material listed in this bibliography which originally appeared in the JOURNAL, but there is no doubt that could this figure be computed, it would be considerably higher than the proportion of our material as a whole computed above. In textbooks on genetics, variation, and evolution the photographic illustrations reprinted from the JOURNAL run from 20 per cent to 50 per cent of all illustrations used.

Those whose support has made possible the publication of the JOURNAL may be encouraged by these dry statistics to feel that it has made a useful and significant contribution to the increase and diffusion of knowledge regarding plant genetics. That the contribution would be as large in the fields of genetics of animals and of man himself seems altogether likely. There is some reason for believing that it would be larger, in the latter field especially.

ROBERT COOK

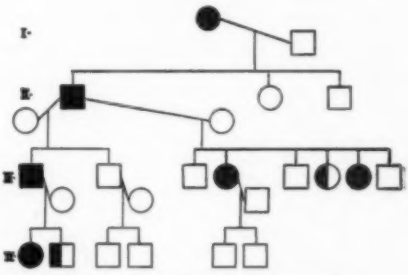
◆

FOUR GENERATIONS OF SHORT THUMBS

LEONARD P. SAYLES and JOSEPH W. JAILER
College of the City of New York

THIS paper presents additional data concerning the inheritance of a type of short fingers already discussed by Breitenbecher[1] and Hefner.[2]

In the present group the terminal phalanx of the thumb is shortened



DOMINANT SHORT THUMBS
Figure 17

*The *Journal of Heredity* (1914—the *American Breeder's Magazine* (1910-1914), and the *Proceedings* of the American Breeder's Association (1904-1912).

ONE SHORT THUMB

Figure 18

X-ray photograph of the thumbs of the male of the fourth generation with the right thumb brachymegalodactylic and the left thumb apparently normal.

and somewhat widened with the result that the whole digit appears squatty. This widening includes the thumb nail. Figure 18 presents an X-ray photograph of both thumbs of one individual in whom the anomaly is confined to the right hand, the left being of ordinary appearance.

In the four generations covered by this study (Figure 17) the anomaly appears in eight individuals. Seven out of seventeen, or a little over forty per cent, of the recorded descendants of the oldest individual included exhibit the trait. Two of these have only one short thumb, the other being of ordinary appearance. In both of these latter cases it is the right thumb which is of the unusual type. The genetic significance of this asymmetrical appearance of the trait is not clear.

Hefner has shown this trait to be a dominant one. Clearly the data presented here are in support of that conclusion. Obviously, too, it is not sex-linked but may be transferred from father to son.

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A BUD VARIANT OF THE SANTA ROSA PLUM

A Late-maturing Form Possibly of Commercial Importance

A. D. SHAMEL and C. S. POMEROY
U. S. Department of Agriculture, Riverside, California

DURING the spring of 1933 our attention was called to a limb sport in an otherwise normal Santa Rosa plum tree. This tree is located near the center of an orchard belonging to A. H. Harlan in the West Yucaipa district of San Bernardino County, California. The limb variant was said to be normal in all characters except that the fruits matured late and had a firmer flesh of a clear light amber color.

The Santa Rosa is one of the Japanese group of plums (*Prunus salicina*). It was originated by Luther Burbank and was introduced by the Fancher Creek Nurseries of Fresno, California in 1907.[1] It is now one of the most popular varieties grown in California both for home use and for shipping purposes.

The Harlan limb variant was noticed about 1923, as soon as the tree containing it came into bearing, because its fruit matured much later than normal. It was fortunate that this abnormal limb was saved and not cut out during pruning or destroyed through accident, disease or climatic hazard, as has often happened under somewhat similar circumstances in the writers' experience.

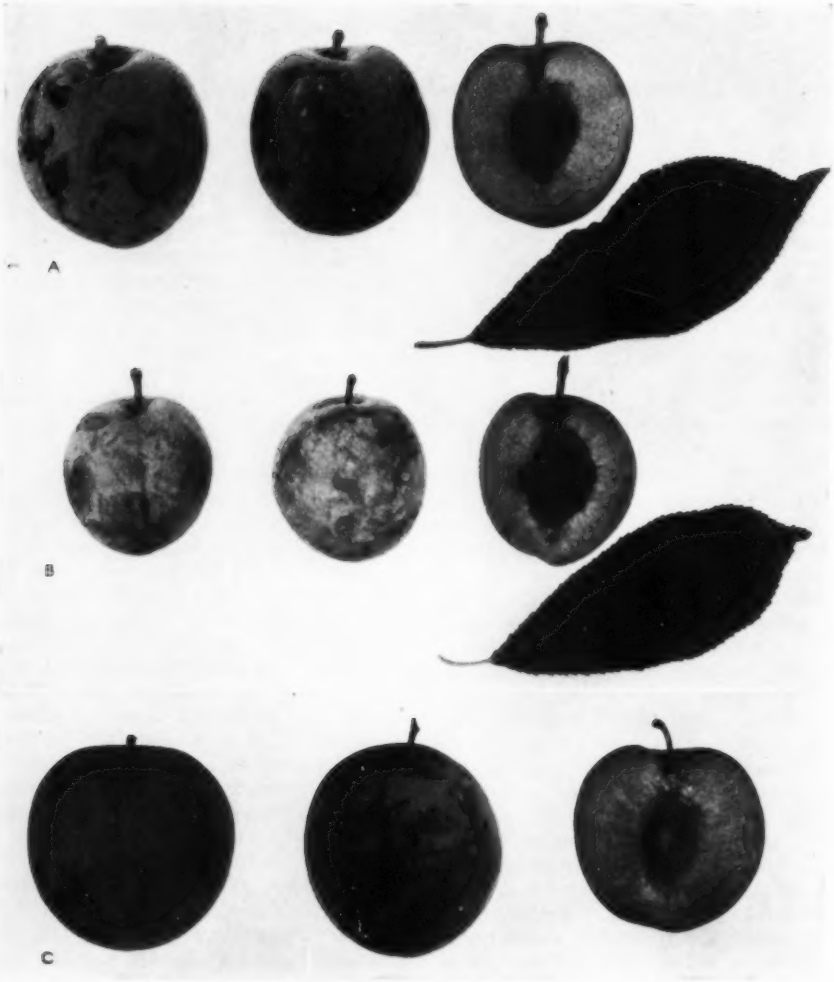
During 1933, three series of observations were made on the performance of the parent tree and of the progeny trees that had been propagated at various times from the limb variant. On June 8, it was found that both of the main limbs of the parent tree and all of the progeny trees bore a heavy crop of fruit, and there were no apparent differences between the fruits borne by the limb sport and those on the normal growth of the parent tree. The parent tree consists of two main limbs about equal in size arising from the trunk at the point where the nursery tree was topped and about a foot from the present ground level. The northerly placed limb is the normal Santa Rosa one, while the southerly one is the variant bearing the late-maturing fruits.

On July 12, the fruits on the normal growth of the parent tree, and those on the other Santa Rosa trees in that orchard, were mature (Figure 19A), and picking was about to begin. The fruits on the limb variant and on the progeny trees propagated from it were, on the other hand, decidedly immature in appearance, small and green with a purplish stripe at the suture, and apparently would not be ready for picking for several weeks (Figure 19B), or, as estimated by Mr. Harlan, until about September 1.

On September 5 the picking of the larger block of progeny trees of the late-maturing strain was under way, the crop of the parent limb and of the older progeny trees having been harvested a few days previously. A sample of seventeen typical first grade fruits was obtained for study and photographing (Figure 19C). These varied in weight from two and one-half to three and one-quarter ounces, their average being two and three-quarters ounces.

Differences in Fruits

So far as we could determine the late-maturing fruits were identical in appearance with the normal Santa Rosa plums that had been harvested about the middle of July, but had a



A LATE MATURING VARIANT OF THE SANTA ROSA PLUM

Figure 19

A—Mature Santa Rosa fruit picked July 12, 1933. *B*—Fruit from the late ripening bud mutation of this variety picked on the same date,—still very immature. *C*—Mature fruits from progeny trees of this variant strain, picked September 5, 1933. The fruit, which in other respects closely resembles the Santa Rosa plums, matured nearly two months later. The suture stripe of the variant form is a distinguishing characteristic and the seeds are a little smaller. The productivity of the variant trees is excellent and the plums keep well. The new form appears to be one of possible commercial importance through lengthening the ripening season for this type of plum. About one-half natural size.

somewhat firmer flesh and a clear light-amber flesh color without the red streaks of the normal Santa Rosa fruits. The fruit characters that were observed in the late-maturing strain include: large size, oval shape, shallow suture, deep purplish-crimson color of the skin with a deeper colored suture stripe. The fruits are coated with a delicate blue bloom, have a firm, light-amber colored flesh, are clingstone, with medium to small smooth seeds and good flavor.

Professor S. A. Skinner,* Mr. Harlan, and others have emphasized their observations as to the firmer, crisper texture of the flesh of the fruits borne by the bud variant as compared with the parent Santa Rosa variety, and their tendency to remain in superior eating and shipping condition for a longer period, both on the trees and in storage. They also express the opinion that the seeds of the sport are smaller than those of comparable Santa Rosa plums, and that the cooked fruits of the variant are not so tart as are the normal ones.

The major point of difference between the normal Santa Rosa plums and those of the variant is the time of maturity. In the Harlan orchard on the parent tree and on progeny trees under comparable cultural conditions this difference amounted to about six weeks this season and according to all first-hand accounts this difference in time of ripening has been approximately the same each season since the variant has been under observation.

The foliage characteristics of the parent limb variant and the progeny trees that have been propagated from it are apparently identical, so far as our observations have gone, with those of the normal Santa Rosa growth.

Origin

The history of the finding of the limb variant is told in the following account by the discoverer and first propagator, Prof. S. A. Skinner, Redlands, California.†

I came into the possession of the grove when it was about two years old (1922). As soon as the trees began to bear my attention was attracted to the portion of the tree blossoming at the same time as the balance of the tree but maturing its fruits several weeks later than the normal branches. At first I considered it as a nuisance but later was impressed with the quality of the fruit and began to watch it carefully. I gave out samples of the fruit for eating and cooking to several neighbors and all found it to be exceptionally fine. I tried to get various nursery companies interested but without success. Finally, I paid the Armstrong Nursery Co., Ontario, California, to propagate 85 trees for me. I also top-worked several Santa Rosa trees. I sold the grove to A. H. Harlan (1930) but have 85 trees not yet in bearing on my own place adjoining that of Mr. Harlan at West Yucaipa. I am positive that no bud was inserted in the parent tree while I owned the place and have no idea that one was ever inserted. It certainly does not look like a root sprout and I am sure that it is not one.

Professor Skinner further says:

About three years ago when I decided to have the sport propagated, I determined to call it Eldora after my wife. The name has not been registered. Subsequent inquiry indicates that this name has already been used for another plum variety. In view of this fact I have suggested the name Eldoris.

A similar appearing plum variation has been reported by C. F. Kinman, Pomologist of the U. S. Department of Agriculture who is stationed at Sacramento, California. Progeny trees of that strain are being grown to a limited extent in Placer County, California and it is said by growers near Penryn to have originated as a bud sport of the Santa Rosa. Mr. Kinman states,‡ "In their dark red color, dots, bloom, yellow meat, size, shape,

*The former owner of this orchard.
†Personal letters, October 19 and 27, 1933.
‡Personal letter, September 13, 1933.

time of ripening, firmness of meat and in fact in almost every respect the fruit from the Penryn trees resembles very closely the fruit you sent from Mr. Harlan's orchard." A sample of the Penryn-grown plums sent by Mr. Kinman to the writers bears out his conclusions as to the similar characteristics of the fruits of the two strains.

It therefore seems likely that at least two strains of the Santa Rosa plum variety exist that originated in a similar manner and at nearly the same time. The writers believe that in all probability other similar sports of this plum have occurred that have been unnoticed or that have not aroused sufficient interest to lead to their propagation. Such occurrences would be in line with experiences in the study of bud variations in other deciduous-fruit varieties and in the citrus.

The Harlan progeny trees from the limb variant in his orchard consist of 22 trees grafted on Santa Rosa plum trunks in 1927 or 1928, two trees grafted on Red Bird peach trunks in the spring of 1931, and 65 trees grafted on Satsuma plum trunks in the spring of 1932. Nearly all of these produced good crops this past season (1933) and Mr. Harlan states that all of the grafts that have fruited have produced plums similar to those on the parent limb variant and that the characteristics of the limb sport have been transmitted through grafting without exception. He says that the progeny trees have consistently borne heavy crops for their age since they first came into fruiting and he has expressed the opinion on several occasions that this strain is a valuable commercial one.

The origin of this late maturing strain of the Santa Rosa plum from a limb sport is a matter of scientific interest and possibly of commercial importance. It emphasizes the desirability of a general search for variant limbs in all fruit-bearing trees and of progeny tests of those that appear to be of value to the orchardist. This variation and many others that have been discovered by fruit growers during recent years indicate a growing interest in this phase of fruit improvement through systematic bud selection. The writers have previously reported on bud variation studies with several other deciduous fruits.[2-7]

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A Glossary Of Technical Terms

Used In This Issue

GENETICS has developed so rapidly that many terms in common use in genetic literature are not yet incorporated in the dictionaries. Many people who are interested in heredity are bothered by such words, for which no definition can conveniently be found. For this reason, it is proposed to publish occasionally a glossary of terms which would not be readily understood and which are not to be found except in new unabridged dictionaries. It is realized that these definitions will probably not meet with universal approval and comments and suggestions will be welcomed.

ALLELOMORPH—Mendelian characters are inherited in alternative pairs, or in alternative series. These alternative genes are called allelomorphs. Examples: Albinism (recessive), Normal pigmentation (dominant); Horns (recessive), Hornlessness (dominant).

AUTOSOME—Any chromosome except the sex-chromosome.

BACKCROSS—Cross of a hybrid to one of the parental forms.

CHARACTER (a contraction of characteristic)—A term used, often rather vaguely, to designate any form, function, or feature of an organism. The Mendelian characters of genetics represent the end-products of development in which a definite gene, or genes, have a decisive effect. "The constant and unchanging thing, therefore, is the factor (gene) itself rather than the character, and the unity which Mendel observed lies rather in this underlying factor than in the visible, and perhaps variable, character which it produces."—Sinnott and Dunn.

DIHETEROZYGOTE—An individual heterozygous for two pairs of genes.

GENOTYPE—The entire genetic constitution, expressed and latent, of an organism.

HETEROGAMETIC—Producing unlike gametes (with respect to the sex chromosome). In the "X-Y" group of organisms the male is the heterogametic sex, producing *X*-bearing sperm and *Y*-bearing sperm in equal numbers. In the "*W-Z*" group (including moths and birds) the female is heterogametic, producing *W*-bearing ova and *Z*-bearing ova, the sperm-cells all carry a *W* chromosome.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two genes of an allelomorphic series. Heterozygous individuals generally resemble the individuals homozygous for the dominant character, but they transmit the recessive to half their offspring.

HOMOZYGOUS—(1) An organism formed by like germ cells; (2) An organism is said to be homozygous for a given character when all the germ cells transmit identical genes for this character. This is the most frequently used meaning of the term.

HYSTRICOMORPH—Having the characteristics of those rodents classified as Hystricomorpha—porcupines, caries, agoutis, chinchillas, etc.

MONOFACTORIAL—Controlled by a single gene (factor) in inheritance.

MUTATION—Where a heritable variation begins. A sudden variation in an inherited character.

MULTIPLE FACTORS—In the expression of some characters more than two genes are necessary. Such cumulative or cooperative genes are called multiple factors. See also *blending inheritance*.

OUTCROSS—A cross to an individual not closely related.

PHENOTYPE—The organism as exemplified by its expressed characters, as contrasted with its genetic constitution (the genotype).

SEGREGATION—Separation of allelomorphic genes at meiosis.

SEX-LINKED—Applied to characters carried on the sex-chromosomes—characterized by typical peculiarities in inheritance as a result of this fact.

SOMATIC—Referring to body tissues; having two sets of chromosomes, one set normally coming from the female parent and one from the male; as contrasted with germ cells having a single set of chromosomes.

SPORT—An abrupt deviation from type.

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